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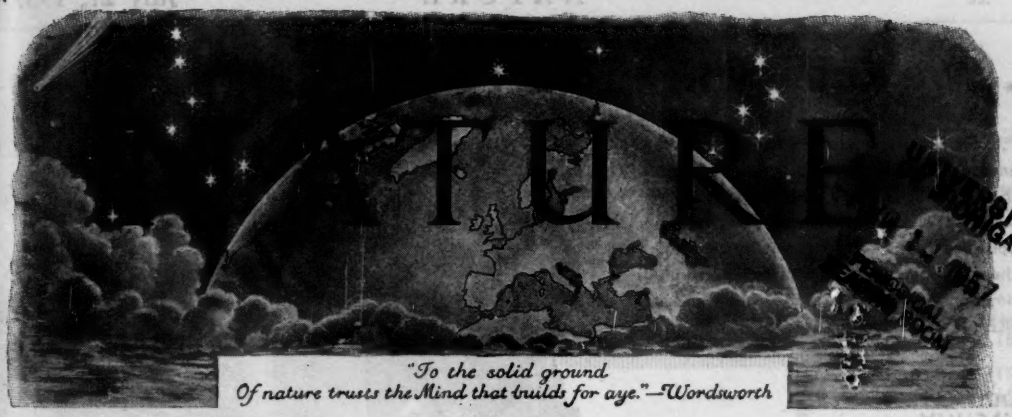

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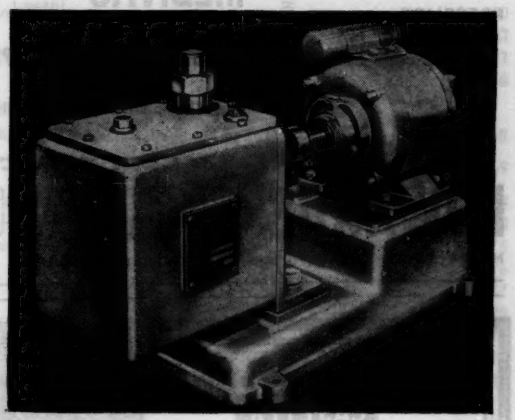

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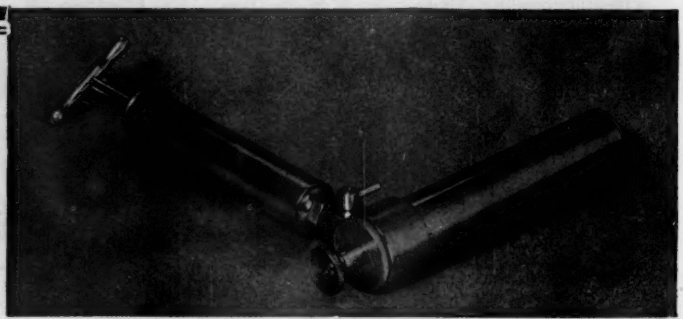

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EDUCATION FOR MANAGEMENT

A FEATURE of recent debates in Parliament on technological and on university education in Britain has been the attention given to training for management; and the emphasis placed on a broad general education, both in these debates and in discussions elsewhere, arises in part from the desire to secure a continuing succession of able administrators and managers both in industry and in the public services, competent to deal with the technical as well as the human issues with which they will be confronted. This concern has been equally manifested in many discussions and debates on technological change and on automation, and particularly in Parliamentary debates on nuclear energy and the Electricity Bill. There, however, the focus of attention was not so much on the educational aspect, as on whether the changes proposed in the structure of the electrical industry would limit the opportunities for its technical staff, and indeed whether this and other nationalized industries could offer the conditions and the opportunities which would attract and hold talent of the highest ability.

Although it is now generally recognized that it is of the utmost importance to ensure a sufficient supply of managers and administrators of the highest ability competent to handle the growing complexity of problems which confront the manager and the administrator to-day, the full implications are far from being appreciated. Quantitatively they were scarcely noted in the report on Scientific and Engineering Man-power in Great Britain last autumn, and the survey of graduate employment undertaken by Political and Economic Planning threw little light on this aspect. Yet, as Sir Edward Appleton noted in his Reith Lectures, to attract able young minds to such careers is an essential part of the problem, and the question of motive might well repay further study. Too much emphasis in this connexion could be placed on the scientific and technical aspects of management problems. There is a moral or altruistic appeal, which has attracted men of the character and intellect required into the professions and into the public service, and which might equally attract such men and women into industry if a little care were taken to show the satisfaction which can be found in co-operation and in tackling the intricate problems of labour relations, design, research and production which management may involve.

These are problems upon which the universities as well as industry should be thinking hard. They affect the content of university education as well as the extent of its expansion, though the fact that the manager and administrator could be drawn from arts graduates as well as from those in science or technology complicates the estimate of demand for particular categories. There is, however, welcome evidence that this is being done. Apart from recent references made to this matter by the chairmen of several leading industrial firms in addressing the annual meetings of shareholders, three recent books* have dealt with various aspects of the problem from what may be described as the employment side; and from the point of view of the educationalist, Dr. B. V. Bowden, while disclaiming any idea that the Manchester College of Science and Technology should prepare ordinary undergraduates for degrees in industrial administration, has set forth clearly the way in which a university department could assist, both in the provision of competent managers and in the study of the enduring difficulties which confront them.

Dr. Bowden suggested that there were six fields of teaching and study in which a university department of industrial administration could help. It should explain to undergraduates in science and engineering something of the social and managerial problems of productive industry. In particular, it could help the technically qualified student who had already entered industry, but who was attending courses at the college on a part-time basis. The third possibility lay in offering a short full-time course for rather older men who had already achieved a position of responsibility, but might be fitted for higher posts. The courses given at the Administrative Staff College at Henley represent a fourth approach to raising the standard of management and preparing men for positions of responsibility on policy-making boards. Then there were courses for foremen, though much of this work might be more suitable for the technical colleges. Lastly, he pointed out that no British university appears to be studying or preparing for the implications of automation, particularly those involved in the application of digital computers.

A survey of company executive development schemes, described in the first of the recent books on management alluded to earlier, was made by the Manchester College of Science and Technology jointly with the British Institute of Management. This survey originated from discussions in the education committee of the British Institute of Management on courses and facilities for education and training for management. Steps taken by individual companies for training their own staff within their own establishments have as great a contribution to make in developing the managers of the future as have courses provided by external educational associations, but whereas fairly full information is available about these latter courses, much less is known about what industry itself is doing. This pilot inquiry was undertaken to ascertain what proportion of companies in the chosen area did systematically provide for

* (1) Company Executive Development Schemes: a survey in North-West England made by the British Institute of Management and the Manchester College of Technology. Pp. vi+164. (London: Management Publications, Ltd., 1957.) 10*s.* 6*d.*

(2) Vitality in Administration. By Herbert Morrison, Basil Smallpeice, Sir Alexander Fleck, Sir Wilfrid Neden, A. D. Bonham-Carter and Major-General G. N. Russell. Pp. 78. (London: George Allen and Unwin, Ltd., 1957.) 8*s.* 6*d.*

(3) The Making of an Administrator. Edited by A. Dunsire. Pp. xv+125. (Manchester: Manchester University Press, 1956. Published on behalf of the Royal Institute of Public Administration, South West of England Regional Group.) 10*s.* 6*d.* net.

managerial succession, and to study in detail a few good schemes in various industries and in firms of various sizes.

The statistical part of the survey was limited to firms employing more than five hundred people, and of the 112 firms interviewed about 36 per cent claimed that they had a definite training scheme; but the interviewer was sometimes left with an impression of vagueness regarding the assessment of managerial requirements and that he had been told what the firm felt it should be doing rather than what it actually was doing. Again, while 74 per cent of the firms claimed that personal audit by higher management was regularly practised, the investigator was again often left with a strong impression that the potential value of this feature was not appreciated. The survey well remarks that the real significance of this statistical study is that the proportion of firms claiming a definite training scheme, even if all such claims could be fully justified, is far too low for so vitally important a matter as ensuring managerial succession.

This position strengthens the argument of Dr. Bowden and others for greater attention to education for management outside industry as well as for co-operation between the universities and colleges of technology and industry. Clearly, for the present, over a large proportion of industry the improvement of management depends on the quality and interest of those entering industry, and on the provision of adequate opportunity for those within industry to return either to a university, a college of technology or to such an institution as the Administrative Staff College at the appropriate moment in their careers. It should be noted, moreover, that in the conclusions drawn from the case studies which occupy the greater part of the book, it is emphasized that, however well conceived a training scheme may be, its ultimate success depends upon the integrity, loyalty and leadership in the existing management. These are essential prerequisites of high morale, which is something to be deliberately evoked and maintained. The value of a sound executive development scheme may be nullified if the trainee has legitimate ground for thinking that management practice is falling far short of the standards which formed the basis of his training, and here the importance of learning by doing rather than observing is stressed. While the trainee needs to acquire a wide perspective of the organization in a short time, he is in danger of becoming frustrated by too long a spell without a job or responsibility of his own in which some initiative may be shown.

This emphasis on the importance of the active interest of the senior management in any such schemes is reflected in the six essays which the Royal Institute of Public Administration has published under the title "Vitality in Administration". In one of these essays, which are derived from a series of lectures which the Institute arranged in London in the spring of 1956, Mr. Basil Smallpeice, managing director of the British Overseas Airways Corporation, makes the bold claim that one nationalized industry at least possesses the vitality of administration which enables it to meet the challenge of intense and unceasing competition, and he suggests that the vitality of an administration is to be judged by the manner and speed with which it responds to the challenge of the changing situations that confront it. Sensitivity of perception, enabling the administration to recognize quickly the existence and nature of a situation calling for action; the ability to decide swiftly the precise action required; and prompt, energetic and efficient execution of the decisions reached are the three characteristics which Mr. Smallpeice considers as essential in any vital administration, and it is obvious that they demand qualities which are essentially personal and largely independent of a particular discipline or field of knowledge in which the administrator may have been trained.

It may be recalled that the Fleck Committee, which two years ago reported on the organization of the National Coal Board, was highly critical of the management of that industry, and was emphatic that, in the main, the industry should throw up its own leaders, and that positive measures should be pursued to that end. The Committee was clearly of the opinion that the industry had not been obtaining its due share of the nation's brain-power and executive ability, and its review brought out particularly the demand made on management for human understanding and for the moral qualities which leadership implies. Sir Alexander Fleck reiterates the emphasis laid in this report on the need for leadership, particularly at the highest level, in the essay on the pressure of technical change which he contributes to this series, and in which he illustrates how vitality in administration is secured and technical change is met in Imperial Chemical Industries, Ltd. Sir Alexander's concept of vitality is essentially creative: it is concerned with new concepts and new policies. The right choice of man, the establishment of mutual confidence, loyalty and discipline, involving close contact and collaboration between policy makers and executive, are primary factors in securing uniformly good management; the establishment of appropriate standards of performance for assessing the quality of management and ensuring that the benefits of a large organization are obtained are the qualities the exercise of which develops and maintains vitality.

Sir Alexander's stress on the need for constant vigilance on the human aspect rather than on organization is of the more interest to scientists in view of the high proportion of scientific and technical staff in Imperial Chemical Industries at every level: of the 7,800 male managerial staff, 5,800 are of this type, and the proportion is growing year by year. Sir Wilfred Neden, looking at human relations in industry as a whole, brings out the positive contribution which such enlightened and vital administration can make particularly in a time of technological change, as indeed was well shown in the study, "Technical Change and Industrial Relations", made by the Department of Social Science of the University of Liverpool. Mr. A. D. Bonham-Carter's essay on "The Motive Power of Higher Management" is

concerned mainly with the means by which top management is kept at the highest efficiency, with particular reference to Unilever, Ltd., while in the last essay, entitled "The Challenge of Organization", Major-General G. N. Russell, general manager of British Road Services, describes the steps taken to forge the human links upon which effective communication really depends.

While these essays display very clearly the qualities which the administrator and the manager is required to exercise, and indicate that in some industries great care is already being taken in the selection of men for positions of high responsibility, they do not on the whole offer much guidance as to the training of a manager or administrator. It can be seen that a scientific or technical training is no bar to advancement to positions of the highest responsibility, and may indeed be a definite asset. Equally it is evident that the manager and administrator need a wide general education which develops not simply technical competence but also human insight, sympathy and judgment.

More light is thrown on the problem of education for management by the five essays delivered at Exeter to commemorate the centenary of the Northcote–Trevelyan report on the organization of the Civil Service, which have now been published under the title "The Making of an Administrator". Of these essays, one by Mr. D. K. Clarke, director of research at the Administrative Staff College, Henley, is concerned with educating the administrator and describes the way the Administrative Staff College works, emphasizing once again that to raise the level of administration it is not enough to add to the knowledge of the administrator : it is necessary to develop the man as a whole. In that essay, however, as well as in others, notably those of Sir Edward Bridges and Lieut.-Col. L. F. Urwick, support can be found for Dr. Bowden's views on the varied courses which universities or colleges of technology could offer ; indeed, one valuable feature of all these books is their contribution to clarifying the function of the university in this field. The appropriate courses cannot be devised without clear ideas not only as to what is required but also when they are to be given, and at what stage in the student's career.

Sir Edward Bridges looks at administration from the point of view of the Civil servant, but his picture of the qualities required is valid for the administrator of any large organization, and although he believes that certain lessons can only be learnt on the job, he is less dubious than Sir Harold Banwell as to the possibility of administration being taught. Col. Urwick, on the other hand, is emphatic that there is a new body of knowledge greater than is commonly realized in industry or elsewhere which can and should be applied to problems of administration. Existing disciplines are not being applied to practical problems as they should, and he instances those which could be used in dealing with the individual task, the adjustment of the individual, the correlation of group tasks, or the energizing of groups, so that facts are assessed objectively before conclusions are reached and judgments are based on facts rather than on prejudices or personal preferences. We have created an adaptive society, he argues, and we cannot live in it with the notions of political and social organization appropriate to a static and established society.

Col. Urwick agrees that leadership can only be learnt by experience and example, by being actually responsible for the work of others under wise and sympathetic guidance, and that this experience, in its initial stages, must come while the individual is young and impressionable. He believes that the demands upon administrative leadership are incomparably greater than they were a century ago, and that there is in consequence an irresistible drive towards larger units of control, with more numerous and multifarious relations with other units and institutions. Educational institutions are, in fact, failing in their task if they do not to some extent assist their students towards that more intricate social discipline which these larger units demand of those who participate in them.

There, indeed, is the core of the reason why technical colleges as well as universities cannot ignore the challenge which training for management offers them. No one pretends that even carefully and elaborately devised training can instil the spark of artistic genius which, in the good administrator, seems to be inborn. Nevertheless, as Mr. A. Dunsire remarks in the comment on the five lectures with which the book concludes, much can be done to produce a satisfactory level of competence in the young administrator in a reasonably short time, by making available the findings of previous practitioners about ways of doing and of acting that they have proved efficacious, and by providing wherever possible facts and figures to supplement the personal experience which he picks up on the job.

What stands out from these studies is the urgency and importance of the problem of improving the standards of management generally, and of ensuring that those with first-rate administrative ability have full opportunity to use and develop their gift. It is a field which offers large possibilities for co-operation between industry and the universities and technological institutions. Training methods may, as Mr. Dunsire notes, be considerably affected by new discoveries about administrative behaviour. While knowledge gained by personal experience may well remain the indispensable groundwork of the success of the administrator, we are far from having exhausted the means of supplementing it. There is a field for research here which university departments as well as the Administrative Staff College might well explore, and the question of training methods and courses in the broad field of management at various levels is one for which due provision must be made in plans for the expansion of British technological education in particular. Similarly, the expansion of university education must take account of the ways and means in our age by which the universities can continue to equip men and women able to face the problems of to-day, and to supply the leader-

ship which is demanded by an age of rapid technological change. Even if judgment cannot be taught, it can at least be fostered, and the immense social importance of sound judgment would in itself justify every effort to encourage its development were it not also true that in fact certain university courses are already noted for their capacity to develop judgment, as well as the vision and understanding that the manager and administrator need in increasing measure to-day.

HOMINIDS AND 'HUMANS'

The Osteodontokeratic Culture of *Australopithecus prometheus*

By Prof. Raymond A. Dart. (Transvaal Museum Memoir, No. 10.) Pp. viii+105. (Pretoria: Transvaal Museum, 1957.) n.p.

OVER the past thirty years the fossil Australopithecinae from the Early Pleistocene of South Africa, because of their remarkably primitive characters, have naturally provoked a good deal of discussion. The continued accession of much more complete skeletal material from limestone deposits in the Transvaal, however, has served to dispel earlier doubts which had been expressed about their taxonomic position, and the general consensus of opinion to-day has been fairly represented by the American palæontologist, Dr. G. G. Simpson, in a recent article (*Science*, April 26, 1957) in which he expresses the opinion that "the accumulated evidence is now overwhelmingly in favour of hominid affinities". But while the australopithecines may be accepted as early representatives of the family Hominidae, it does not necessarily follow that such terms as 'human' or 'man' can properly be applied to them. It is important to emphasize this distinction, for much confusion has unhappily been introduced into discussions on hominid evolution by the careless use of these colloquial terms. If it is agreed that the term 'man' should be reserved for those more advanced stages of hominid evolution characterized by the ability to fabricate tools, it is clearly not applicable to such primitive hominids as the australopithecines unless it can be demonstrated that they were tool makers.

The evidence which has so far been adduced for such a conclusion has either proved to be faulty, or, at the most, no more than suggestive. Prof. Dart, in his monograph on the bone breccia from the australopithecine deposits at Makapan, insists that it is much more than suggestive, for he claims that the rich assortment of animal remains from this breccia bears witness to an elaborate bone culture. But it is one thing to show, as Dart endeavours to do, that these fragments of bones and jaws could have been used as tools and weapons, and quite another thing to prove that they were used as such. Without doubt, Dart goes far beyond the legitimate limits of his evidence in propounding these claims, and it is a pity that this should be so, for his undue emphasis on this aspect of his studies obscures the more important parts of his monograph. It is unfortunate, also, that this over-emphatic style of writing must inevitably prejudice the reader against some of his quite legitimate inferences. The latter are concerned with the general nature and composition of the bone breccia. In the first place, Dart casts serious doubt on the suggestion that the accumulation of animal bones could have resulted from the activities of hyænas in occupation of the Makapan caves, or that they were carried in by porcupines. Here his argument is based on observations on the natural habits of these creatures to-day—there is no good evidence that they ever accumulate bony fragments of the kind, or in the number, found in the Makapan breccia.

Could the latter then be the relics of the hunting activities of the australopithecines? This is Dart's contention, and he seeks to test his conclusions by a most interesting analysis of the composition of the bone breccia in terms of the comparative frequencies of different skeletal elements of different animals. For example, he finds that 92 per cent of the total fragments recovered are those of Bovidae, and of 163 vertebral fragments of these animals 56 per cent are cervical vertebrae (as against 44 per cent of the thoraco-lumbo-sacral series). Moreover, about half the cervical vertebrae are the first and second (atlases and axes). From such data he infers that the bovid heads with a few of the adjacent cervical vertebrae must have been severed from the body before being carried off to the cave. Again, he finds great discrepancies numerically in the limb fragments—for example, 336 humeri as compared with 56 femora—and argues that this implies a selection of limb parts for the use which could be made of the bones as weapons. The quantities of bone flakes, many of them sharply pointed, he attributes to deliberate and systematic manufacture for use as flake tools, if only because there does not appear to be any other ready explanation for them.

Similar interpretations based on similar bone deposits have been put forward on previous occasions by archæologists. For example, Abbé Breuil, writing in the *Bulletin of the Geological Society* of China in 1931, supposed the bone flakes found in association with the remains of Pekin man at Choukoutien to be evidence of a bone-flake culture. In this case, however, some critics suggested that, before accepting such a conclusion, it would be well to examine bone breccias formed under conditions which would exclude all possibility of human agency, and no doubt the same criticism might be advanced in reference to Dart's conclusions. But if Dart, in pointing the way to the study of bone breccias by a statistical analysis of their composition, stimulates comparable studies on an extensive scale, his monograph will have served a most useful and important purpose. It may be, indeed, that the results of such comparisons will add support to his contentions that the australopithecines were sufficiently advanced to have established a veritable bone culture. For the moment, however, such a claim is surely premature.

W. E. Le Gros Clark

THE NEW PHYSICS

An Approach to Modern Physics

By Prof. E. N. da C. Andrade. Pp. ix+232+16 plates. (London: G. Bell and Sons, Ltd., 1956.) 25*s*. net.

PHYSICS has advanced a long way since Andrade's book, "The Mechanism of Nature", first appeared in 1930. Then was a time of rapid advance, based on the new fundamental principles of the quantum theory, which had become sufficiently clarified in 1925 to bring order into much that had been chaotic. Now is a time of scarcely less rapid advance, relying

for the most part on the same principles, no longer new, but still vital. Prof. Andrade's new book, "An Approach to Modern Physics", reflects the change. It is based on the earlier book, incorporating new material on such branches of physics as nuclear structure, elementary particles, and solids and liquids, in which considerable advances have been made in the past thirty years.

The scheme of the book is to single out a few of the basic conceptions of physics, and to devote a chapter to each. This approach gives a broad historical perspective of the development of physics without being circumscribed by chronology. The many interrelations between the ideas of the different chapters are admirably worked in. It starts and ends with philosophical chapters. "What is physics ?" is the question answered in the first chapter. The leading ideas of nineteenth- and twentieth-century physics —the nature of heat and of light, waves, electricity and atoms, quanta, the structure of the nucleus— are then introduced. The later chapters become more factual (for example, there is an account of the working of nuclear reactors), more concerned with reporting recent advances, and less reflective. The final chapter ("Uncertainty") is metaphysical, and an affirmation of a personal faith into which is interwoven a somewhat perfunctory discussion of the philosophical problems raised by quantum physics.

It is a pleasure to be able to read a popularization of physics so well thought out and written. It demónstrates that science and literature can still be combined in one work. The approach is often fresh, and the language always simple and graceful, without giving false impressions. The standard of excellence is by no means uniform, however, and one cannot resist the impression that the later chapters have received less polish than the earlier ones, letting in a few mis-statements and some rather facile judgments not in keeping with the standards of the earlier part.

I recommend the book both to the layman and to the student of science. The one will find in it a very readable account of the important concepts of physics; and the other will be made to see familiar ideas with a sharpened perception. M. H. L. PRYCE

THE HARVEY SOCIETY OF NEW YORK

The Harvey Lectures, Series 50 (1954–1955)

Delivered under the auspices of the Harvey Society of New York. By Dr. Vincent du Vigneaud, Dr. Richard J. Bing, Dr. J. L. Oncley, Prof. André Lwoff, Dr. Ephraim Shorr, Dr. George O. Gey, Dr. Bernard D. Davis, Dr. David Shemin, and Dr. Eugene L. Opie. Pp. viii+421. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1956.) 8 dollars.

THE Harvey Society of New York was founded fifty-two years ago with the object of fostering "the diffusion of scientific knowledge in selected chapters in anatomy, physiology, pathology, bacteriology, pharmacology, and physiological and pathological chemistry, through the medium of public lectures by men who are workers in the subjects presented". These laudable aims have been faithfully pursued, and realized, since the foundation of the Society, as testified by a complete list of the lectures in each year since 1905, which is included in the present volume. The Society has been admirably served by men of eminence in the various fields, and the titles of past lectures form an interesting reflexion of the climate of thought in the medical sciences over a period of great activity and progress. The collected lectures for 1954–55 illustrate the wide field covered by the Society, and in this series the emphasis rests to a considerable extent on metabolic and biochemical aspects, with considerable attention to bacteriological and cytological aspects. Specifically, the contents contain accounts of lectures on the hormones of the posterior lobe of the pituitary gland, heart metabolism, lipoproteins of human plasma, viral diseases of bacteria, metabolism of ferritin, continuous culture of normal and malignant cells, biochemical applications of bacterial mutants, porphyrins, and the conditions determining water movements into and out of cells. In addition, an address on the Harvey Society, on the occasion of its fiftieth anniversary, is included in this series. It would perhaps not be ungracious to note a slight geographical inaccuracy in the text, in which Lord Adrian is described as Master of Trinity College, Oxford. The format is attractive, there are adequate numbers of diagrams and illustrations, and although the material is, in places, highly concentrated, the spirit of the original lectures would appear to have been retained.

To the busy worker in a particular field, the accessibility in one volume of a wide variety of authoritative reports of recent work is an encouragement to wider appreciation of selected fields of effort, which is regrettably becoming progressively more difficult to realize. W. BURNS

LOVE AND SOCIETY

The Direction of Human Development

Biological and Social Bases. By Prof. M. F. Ashley Montagu. Pp. xi+404. (London: C. A. Watts and Co., Ltd., 1957.) 28*s*. net.

THE study of human behaviour and the structure of human societies, in ways that are in keeping with the requirements of scholarship and scientific inquiry, has always tended to be overshadowed by the speculations of those who feel themselves burdened with a mission for the reformation of the world around them or possessed with an insight which gives them a unique clue to the springs of human behaviour. Sometimes, indeed, the social 'scientist' becomes a propagandist or a prophet, and a muddle is thus created which may cause confusion in the minds of his colleagues and students. Another example of this kind is now presented to us in the work of Prof. Ashley Montagu, director of research, New Jersey Committee for Physical Development and Mental Health. His book is based on lectures given in 1944, in what has since become the Harvard University Department of Social Relations. In the course of delivering them, Prof. Montagu found that human nature became understandable to him for the first time; after ten further years of deliberation he has produced what is stated on the dust cover of the book to be an approach to "a scientific validation of the importance of love in all human affairs". His end is propagandist, but his method is pseudo-scientific; he faces himself with the task of distilling

a value-judgment from scientific work and, needless to say, he fails to do so. He seeks to show that "human beings are born good", and he does so by defining 'good' as the "need to be loved and to love others".

There is, Prof. Montagu recognizes, nothing new in this formulation. What is new, according to him, "is that the meaning of love should have been rediscovered in the twentieth century by scientific means". But he proceeds, not by demonstration, but by circular definition. For 'love' is, for him, the "form of behaviour that contributes to the healthy development of both the lover and the loved", while 'health' consists in "the ability to love and the ability to work".

Furthermore, he faces himself with the problem that if men are born good, how is it that the societies in which they live (notably, according to Prof. Montagu, the American society) are so bad? His answer is no more satisfactory than those of the array of philosophers who have broken their intellectual teeth on this in past ages. He argues that men are made bad by miseducation, adding a brief jeremiad directed against the American system. The social millennium might be produced, he suggests, if children were educated in the arts of human relations, in ways which remind one somewhat of the precepts of Mr. Dale Carnegie. "To produce loving human beings should be the primary purpose of education." But how are human beings, who have been miseducated into error, to educate their children into the way of truth, even when fortified by Prof. Montagu with the knowledge that "Love is God"? That is a problem that can only be tackled by persons possessing a greater measure of sophistication than is at his command.

T. S. Simey

SUBJECTIVE PROBABILITY

Risk and Gambling

The Study of Subjective Probability. By Prof. John Cohen and Mark Hansel. Pp. x+153. (London: Longmans, Green and Co., Ltd., 1956.) 14*s*. net.

THAT 'probability is the guide to life' is now being taken seriously by psychologists. Ever since, and no doubt before, Sir Ronald Fisher's pronouncement that "inductive inference is the only process . . . by which new knowledge comes into the world" it might have been clear that inductive logic and probability theory should be serious candidates for forming the basis of learning theory. In fact, the major theories of learning have only introduced probability considerations as an afterthought, their preoccupation being with such concepts as drive, goal-seeking, reward and punishment. The experimental study of learning has—at least in animals—developed from physiology, and here the conditioned reflex of Pavlov has had a not altogether happy pre-eminence. It early became clear to students of behaviour that the classical Pavlovian situation, in which dogs were allowed only minimum freedom of movement and all distraction was avoided, could not afford a complete paradigm, where exploration was evidently so important.

The learning theorists of this period tended to regard Pavlovian conditioning as somehow the essential physiological basis of all learning, but requiring extra concepts, such as drive states, to describe the animal outside Pavlov's laboratory. J. B. Watson, of behaviourism fame, attempted to describe human learning in terms of chains of conditioned reflexes, all ultimately links from, and extensions of, a few innate and primary reflexes such as fear of falling and fear of loud sounds. Although influential, this failed if only because it could not explain increasing variety of effective stimuli ('stimulus generalization') for a given response, or learning by example.

If learning is regarded not as the building up of reflexes, or of 'links', but rather of conditional probabilities, then at once we have a simple formal language which seems appropriate for describing basic learning phenomena, including conditioning. The frequencies of 'input' and 'output' events can be described with the familiar probability calculus and we all know what we are talking about. We can also perhaps usefully compare animals and men with practical inductive machines, such as 'totes'. A. M. Uttley has built a special inductive machine which demonstrates many features of learning, and brings out some of the necessary logical and engineering conditions for a practical conditional probability inference device which might be accepted as a true 'learning machine'.

Once we have such a simple picture of learning as essentially gambling, then we may readily imagine an 'ideal learner', and this we may use as a reference for estimating the efficiency and the failures of actual animals, men and machines. Thus the study of subjective probability (or the probability or betting behaviour of men and animals making decisions) is highly important. The tragedy of the present book is that the live and fascinating issues in contemporary behaviour theory are not mentioned, and neither is the now large experimental literature. All that is given is an account of some experiments undertaken over the past few years by the authors themselves. Some of these are ingenious and apparently well planned, but they are given in a vacuum—a vacuum that might well be abhorred by Nature.

One of the most interesting experiments described concerns the behaviour of pedestrians at road crossings under various traffic conditions—an ideal life-and-death decision situation where the experimenter does not influence the situation since he can observe from some upper window—but the Road Research Laboratory has undertaken a long series of similar experiments, with most interesting results, and these receive no mention in this book. The book is perhaps intended for a non-serious audience, but the experimental data are given in numerous tables. These are very difficult to interpret or evaluate, for no statistical details are provided, mean values apparently being considered sufficient. The result is a lack of even tentative conclusions.

It is to be hoped that there may soon be a book summarizing the rapidly growing experimental literature, and relating this work with behaviour and learning theory and, perhaps, with the mathematical theory of communication. It is to be hoped that this new book might mention J. S. Mill, and Baye's axiom, as well as some of the experiments of at least B. F. Skinner, E. Brunswik, J. S. Bruner, W. K. Estes and J. W. Whitfield. One chapter might describe the changes produced in the old stimulus-response model by probability considerations.

R. L. Gregory

The Birds of the British Isles

By Dr. David Armitage Bannerman. Illustrated by George E. Lodge. Vol. 6: Ciconiidae, Ardeidae, Phoenicopteridae, Anatidae (Part). Pp. x+326+26 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1957.) 63*s*. net.

IN this volume Dr. Bannerman maintains the quality and interest of his text, and the pictures by the late George Lodge have their usual excellence. The first part gives an account of the storks and their allies, including only one common British bird, the heron, and one locally breeding species, the bittern. All the rest—herons and bitterns of other species, egrets, storks, glossy ibis and flamingo—have only a vagrant status in our area: a few are found in the nearer Continental countries, but the others are scarce or rare wanderers from southern Europe, or perchance from Africa, with one from America. Nevertheless, each is dealt with in full, the author drawing both on the literature and on his own extensive experience abroad. It may well be from some West African swamp that he has taken his true-to-life description of the squacco heron—inconspicuously buff at rest, but suddenly exploding into white as it opens its wings.

The second part of the volume covers a larger number of familiar species—albeit many of them only winter visitors—in the swans, geese and shelduck. The account of the barnacle goose in its native Arctic quotes at length (by permission) from Salomonsen's book on the birds of Greenland, a work to which many ornithologists in Britain do not have ready access; and the habits of other northern species are likewise fully described from various sources. The section on the shelduck includes an essay, contributed by Mr. R. A. H. Coombes, on the remarkable pre-moult migration which takes the majority of British adult birds to the sandbanks of the Heligoland Bight in late summer. LANDSBOROUGH THOMSON

Times and Places

By the late Harold Peake and Herbert John Fleure. (The Corridors of Time, Vol. 10.) Pp. xv+336. (Oxford: Clarendon Press; London: Oxford University Press, 1956.) 42*s*. net.

THE author of this book has set himself a more than difficult task, and the measure of his success is the measure of his great knowledge and skill. The "Corridors of Time" consisted of a number of slim volumes, each devoted to a particular period of prehistoric development, written by the present author and the late Harold Peake. In the nature of the case, some volumes covered a larger geographical area than others, according to what archæological information was available at the time of printing. Of course, even then all that was known could not be included for lack of space, and the general picture given was what had grown up in the authors' minds. Much has happened since the first "Corridor of Time" was published—indeed, since the last saw the light of day. Not only has information come in apace, but also the general outlook on prehistory is rapidly changing.

In the first part of the present book Prof. Fleure makes a gallant attempt to bring a former volume dealing with the evolution of man and the cultures of the Old Stone Age up to date; the second half consists of a number of chapters devoted to the later prehistory of various geographical areas—South-West Asia, North Africa, the Mediterranean region, India, China and the Pacific. America is intentionally omitted and South African prehistory is barely mentioned. The result is a book which is very readable and, so far as it goes, one which gives an excellent summary of past ages over large areas in the old world. For the specialist, however, it is to be feared that the days of such a general survey are past; too much is now known to make such a work really possible. But for the intelligent amateur "Times and Places" is to be recommended. M. C. BURKITT

Physical Organic Chemistry

By Prof. Jack Hine. Pp. xiv+497. (London: McGraw-Hill Publishing Company, Ltd., 1956.) 67*s*. 6*d*.

THIS book gives a clear and detailed account of a field of work which has been attracting attention both from the theoretical and experimental aspects. Much of the work is modern and it is very useful to have such a summary of it. The experimental material is adequately surveyed, and there are many useful tables and curves. More than half the book deals with polar reactions, but free-radical reactions are included, and there is a separate treatment of four-centred reactions. The author has adopted the plan of treating a selected number of reactions in detail, but the concise discussion of others and the abundant references to literature make the book complete in its field. It is addressed to advanced undergraduates, graduate students, and industrial chemists, and it should fulfil its purpose in providing such readers with an intelligible account of an important aspect of modern organic chemistry. It emphasizes the mechanisms of organic reactions and the effect of structure on reactivity. Physical chemists will also find the accounts of the theory of acids and bases and general and specific acid-base catalysis of interest. This book can be recommended both to students and teachers as a very good survey of its field. The elegant style in which the equations and formulæ are set out makes the book pleasant to read.

J. R. PARTINGTON

Seeds of Life

The Story of Sex in Nature from the Amœba to Man. By John Langdon-Davies. Pp. xix+172. (London: C. A. Watts and Co., Ltd., 1957.) 12*s*. 6*d*. net.

HIS many friends will be disappointed by John Langdon-Davies's latest book. This, despite the fact that the theme is well chosen, the text well planned and written with that skill and fluency for which the author is well known. It is over the manner of presentation that the reader will be unenthusiastic. The book contains no diagrams, no photographs and no index. It may well have been the publisher's intention to present the absorbing story of sex in animals and man as a simple narrative; his wisdom in so doing without any visual aids to understanding can fairly be questioned. The purpose of a book of this kind should be to leave the reader with a sense of beauty and of wonder, and a body of knowledge. There is much evidence to show that one clearly labelled diagram conveys more information about the reproductive cycle in man than many pages of text to be found in a book such as this. Presumably, the form of the book has been dictated by economy; one fails to see how the publisher hopes to sell it in competition with the well-known cheap paper-backs which are copiously illustrated.

T. H. HAWKINS

THOMAS YOUNG AND THE THEORY OF DIFFRACTION

By Prof. A. RUBINOWICZ

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"He [Thomas Young] was one of the most acute men who ever lived, but had the misfortune to be too far in advance of his contemporaries. They looked on him with astonishment, but could not follow his bold speculations, and thus a mass of his most important thoughts remained buried and forgotten in the Transactions of the Royal Society until a later generation by slow degrees arrived at the rediscovery of his discoveries, and came to appreciate the force of his arguments and the accuracy of his conclusions".

(H. Helmholtz, Popular Lectures)

WHEN Helmholtz[1] wrote the above words in 1868, he probably did not expect that after almost a century there would still be some of Thomas Young's scientific attainments which were not generally recognized. Of all the great discoveries we owe to Thomas Young and which have not been duly appreciated by succeeding generations, it was his diffraction theory which had to wait longest to become fully and entirely acknowledged.

Unfortunately, this fact seems not to have become sufficiently known. I was indeed greatly surprised to read, in a recently published biography which contained a deep appreciation of the work of this great discoverer and scientist, that Young's diffraction theory was untenable (Wood[2], p. 166), and that Fresnel's views must be regarded as superseding Young's explanation (Wood[2], p. 195). The same opinion is also expressed in almost all text-books on experimental physics. Only a few text-books on theoretical optics (see, for example, reference 3) give appropriate recognition to Young's contributions to the theory of diffraction. Since for some time past, and particularly recently in connexion with the preparation of a monograph[4] on the subject, I have been interested in the theory of diffracted waves, I should like to outline the origin of Young's ideas and their importance to the modern theory of diffraction.

Young's greatest contribution to diffraction theory lies in the fact that he was the first to give an explanation of the phenomena of diffraction on the basis of the wave theory of light. He started (Works[5], 1, p. 80) from the fact, known already to Newton, that an illuminated edge of a diffracting screen shines, and is thus a source of wave motion. He assumed that the diffraction phenomena arise as the result of the interference of two waves. The first, which may be termed the direct incident wave, is found at all points of space in which light is present according to the laws of geometrical optics, where it is described by the same wave function as in the case of undisturbed propagation of light. This wave motion is discontinuous across the boundary of the geometrical shadow, since there is a sudden change from light to darkness. The second wave motion, termed the diffracted wave, is represented by a wave diverging from the illuminated edge of the diffracting screen. Young[5] (1801) assumed that this wave motion is continuous everywhere, even across the boundary of the shadow.

This splitting of the light into two parts can be found already in Newton's[6] theory of diffraction, constructed on the basis of his corpuscular theory of light. The direct incident light is, according to Newton, due to the light corpuscles which, at any distance far from the diffracting edge, are not deflected by it, but move undisturbed along straight paths. On the other hand, the diffracted wave consists of the light corpuscles which pass in the immediate neighbourhood of the diffracting edge, and are thus deflected by it from their initial paths.

That Young's explanation suggests itself, so to speak, is shown by the fact that Fresnel[7] (1816), in his first paper on diffraction, independently hit upon it himself. However, already in 1816, in an appendix to that paper, Fresnel came to the conclusion that this explanation could not be upheld by the experimental facts. He therefore replaced it by a combination of the interference principle with Huygens's envelope principle. According to Fresnel, it may be imagined that the wave motion arises as a result of interference of secondary waves diverging from all points of a surface extending over the diffracting aperture. It is seen that a wave motion arising in this manner is continuous everywhere, and therefore across the boundary of the shadow too. As is known, Young himself finally came to the conclusion that Fresnel's views were superior to his own and communicated this to Fresnel in a letter dated October 16, 1819 (Works[5], 1, p. 393).

Young and Fresnel agree that the wave motion in the incident wave, as well as in the secondary waves, is given by an elementary law. If, however, we suppose that the motion of light must be described not by an elementary law, but by a partial differential equation, then we must regard only Fresnel's, and not Young's, point of view as justified. In the field of partial differential equations every discontinuity is caused by a physical factor; in the case of the scalar wave equation such factors are simple and double sources. But it is impossible on these lines to give a reasonable physical explanation for the discontinuity of the incident wave which appears at the boundary of the geometrical shadow in Young's theory of diffraction.

Thus it is understandable that when Kirchhoff[8] in 1882 set about building up a theory of diffraction based on the scalar wave equation, he quite automatically arrived at a development of Fresnel's ideas. The Kirchhoff–Huygens principle may be regarded as a matching of Fresnel's ideas to wave equation theory. In this manner the fate of Young's views was sealed for many years to come.

However, even in Kirchhoff's own works[9] we find, in connexion with the diffraction by a screen in the shape of a strip, the remark that "the position of the maxima and minima of the inner fringes (i.e., in the shadow of the strip) is the same as if they were caused by the interference of the rays diverging from the points at both edges of the screen. From this comes the first, indeed imperfect, attempt by Thomas Young to explain the phenomenon which we are considering".

A change in the appreciation of Young's views was brought about by the doctorate thesis of Eugen Maey[10]

(Königsberg, 1893). Starting from Kirchhoff's theory, he established, in the special case of diffraction on a straight edge, the existence of a diffracted wave diverging from points on the edge. He proved theoretically and confirmed experimentally that the incident light is reflected by the straight edge into light cones, in the same way as from a straight cylindrical rod according to geometrical optics.

Next, in 1896, A. Sommerfeld[11], who studied at Königsberg at the same time, obtained an exact solution of the boundary problem for the diffraction of electromagnetic waves by a perfectly conducting half-plane, and in this way became the founder of the exact theory of diffraction. In accordance with Thomas Young's ideas, even the exact solution of Sommerfeld can be split into an incident wave, defined in the sense of geometrical optics, and a diffracted wave diverging from the edge of the screen. Sommerfeld formulated the problem of diffraction as a boundary problem in the field of Maxwell's equations. This explains why, in his theory, discontinuities at the boundary of the geometrical shadow could not occur, since there they would have to be interpreted as electric and magnetic charges and currents. Sommerfeld's diffracted wave must therefore compensate for the discontinuity of the incident wave at the boundary of the shadow, and thus must be discontinuous there, contrary to Young's assumption.

The question of the correctness of Young's views was clarified when it proved possible to split, in an exact way, the wave motion given by Kirchhoff's diffraction theory—that is, by his surface integral over the diffracting aperture—into an incident wave defined in the sense of geometrical optics and a diffracted wave diverging from the edge of the screen (reference 12). If Kirchhoff's diffraction theory is regarded as a precise formulation of Fresnel's ideas, then the transformation given must be regarded as a precise formulation of Young's views (cf. v. Laue[13]). Therefore, the views of Young and Fresnel are fully equivalent: neither can be given a privileged position. It is clear that the transformation of the Kirchhoff integral, as well as the Kirchhoff integral itself, provides a wave motion that is continuous everywhere in space except at the source of light. Hence, the diffracted wave in this case also must compensate for the discontinuity in the incident wave across the boundary of the shadow.

Using the traditional form of Kirchhoff's diffraction theory, the physicists restricted themselves to the calculation of Kirchhoff's surface integral for such special diffraction problems as diffraction at a slit, strip, circular aperture, or a circular screen. Since the diffracted wave is given by a line integral taken along the diffracting edge, and since a line integral is, in general, much easier to evaluate than a surface integral, it proved possible[14] to find the properties of the diffracted wave, and thus also to explain the nature of the diffraction phenomena for a very broad class of diffracting screens. Accordingly, light falling from a source on some definite segment of the diffracting edge may be regarded as reflected in reflexion cones. The diffraction phenomenon arises, at a given point of observation, as a result of the interference of the incident wave (if it exists there) with the diffracted waves diverging from those points of the diffracting edge which reflect the incident wave towards the observation point in question. These points on the diffracting edge, which we shall call 'active points', are so situated that the sum of the two distances from light source to active point and from active point to observation point has an extreme value. Thus the Fermat principle is valid here, just as in the case of reflexion by a plane in geometrical optics. It must be noted, however, that exactly as in the case of a wave reflected by a plane, the contribution to a reflexion cone comes not only from the active point itself, but also from the immediate neighbourhood of this point. We shall call this neighbourhood the 'active region' of the active point.

Since the diffracted wave must compensate for the discontinuity occurring across the boundary of the shadow, it is clear that its amplitude there must achieve the same order of magnitude as that of the incident wave. Calculation shows that the absolute values of the amplitudes of the diffracted wave on either side of the boundary of the shadow are equal to half the amplitude of the incident wave. In order that the discontinuity of the incident wave be compensated, the phases of the incident and diffracted waves must be opposite when approaching the boundary of the shadow from the side of the light cone, and must be equal when approaching from the side of the shadow. Therefore, the diffracted wave suffers at the boundary of the shadow a sudden change in phase of magnitude π.

In agreement with the fact that the diffraction phenomena are most marked at the boundary of the shadow, the amplitude of the diffracted wave falls off rapidly with the distance from the boundary of the shadow. The above-mentioned phase difference π between the two parts of the diffracted wave on either side of the boundary of the shadow is also maintained in these points of space.

If the part of the diffracting edge, containing the active region of an active point, is sufficiently straight, then the intensity distribution on the reflexion cone is given by the well-known Fresnel integral. This explains why it is met so frequently in diffraction theory.

Experiment confirms all these properties of the diffracted wave. That there indeed exists a wave motion diverging from the diffracting edge is confirmed by the shining of the diffracting edge when it is observed from the shadow or from the light cone. In the latter case, however, the eye must be protected against the direct incident light wave. A very elegant objective proof of the existence of the diffracted wave was given by Kalaschnikow[15] in 1912. He observed on a photographic plate the shadows of appropriately situated wires produced by the light of the diffracted wave coming from a diffraction edge. The positions of the shadows showed that the light responsible for them came from the diffracting edge.

The existence of active regions on the diffracting edge is corroborated by the experimental fact that, for a given point of observation, the only regions of the edge which shine are those about the points for which the above-mentioned sum of the distances has an extreme value[14]. Assume, for example, that the screen is circular and the light source is situated on the straight line perpendicular to the plane of the circle and passing through its centre. There may then be seen two shining points which are situated at each end of a diameter, and which correspond to the maximum and minimum values of the sum of the distances.

The existence of a change in phase of magnitude π between the parts of the diffracted wave in the light cone and in the shadow, respectively, can be confirmed

by obtaining an image of the diffracting edge by means of the entire diffracted wave, with the direct incident light excluded. Since the parts of the diffracted wave cancel each other by interference, the diffracting edge appears as a dark line (reference 16). A suitable arrangement for such an experiment is afforded by Toeplers's method of striæ. This method makes it possible to eliminate the direct incident light and to observe the physical processes in the light of the diffracted wave.

All these are facts which are not easily explained from the Fresnel point of view, but which follow directly from Young's theory. They provide unequivocal evidence of the correctness of his hypothesis.

The last stage in the history of incorporating Young's ideas into the theory of diffraction phenomena has only begun. It will have to deal with the question of how far Young's diffraction theory can be justified by the exact theory of diffraction. The fact that the solution of Sommerfeld's diffraction problem is completely in accord with Young's theory is rather an exception. In general, we can merely expect approximate agreement. One may hope that this expectation will be fulfilled in the case of the diffraction of electromagnetic waves, at least for perfect or nearly perfect conductors. The integral equations which can in this case be given for the surface currents may be solved by approximation methods. The wave motion corresponding to this current distribution can be approximately represented[17] by a Fresnel integral, which can be regarded as an infallible sign of the existence of the diffracted wave.

The reality of the diffracted wave can thus be regarded as confirmed, both theoretically and experimentally. The structure of the diffracted wave, it is true, is not exactly like that imagined by Young. Nevertheless, it does not diminish Young's great achievement in the theory of diffraction, namely, to have shown that the diffraction phenomena can be explained at least in outline by the diffracted wave and the interference principle. Every great idea is subject to a process of development in the course of time. The fact that Young's idea could be developed without losing its original character is proof of its strength. The seed which Young has sown in diffraction theory has given a rich harvest.

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SIR DAVID PRAIN, 1857–1944

By Dr. GEORGE TAYLOR

Director, Royal Botanic Gardens, Kew

THE centenary of the birth of Sir David Prain fell on July 11, and it is appropriate to recall the great services to botanical science of the fourth director of the Royal Botanic Gardens, Kew—a post which he held for nearly seventeen years. Prain's choice of a botanical career, which brought him such eminence, was largely influenced by Prof. J. W. H. Trail, who was professor of botany at Aberdeen. Trail had advised him during his arts course to register as a medical student and he did so without any intention at that time of proceeding to a degree. In 1878 Prain obtained the degree of M.A. with honours in natural science and for the next two years he was a schoolmaster at Ramsgate. In this period, with typical Scottish prudence, he saved enough money to enable him to return to his *alma mater* and to obtain full medical qualifications in 1882.

At this stage Trail again took a hand in shaping the destiny of his student by recommending Prain to Sir George King, superintendent of the Royal Botanic Garden, Calcutta, who happened to be on leave and asked Trail if he knew of any medical graduates with a bent for botany who would be inclined to join the Indian Medical Service. Thus it was that Prain entered the competition, was successful, and left to take up his medical appointment in 1885. This led eventually in 1898 to his succession to King as superintendent of the Calcutta Botanic Garden and also in the posts of quinologist, professor of botany at the Medical College in Calcutta, and director of the Botanical Survey of India.

So Prain followed the well-worn and traditional path from medicine to complete dedication to botany. Among his predecessors as head of the Calcutta Garden, each with a similar medical background, were his fellow-countrymen Roxburgh, Buchanan-Hamilton, Thomson and King. Prain held his offices in Calcutta for some seven years and, judged from the number of publications which he produced despite his heavy administrative duties, it was a period of great activity, though he did surprisingly little travel. He was able, however, to visit southern India and was also fortunate enough to collect around Khambajong in 1903 on the Tibetan plateau, where Sir Francis Younghusband was encamped while waiting to negotiate with the representatives of Tibet. On this visit Prain arranged for collecting to be continued by Col. Waddell and Capt. Walton, and the material, the first to reach Britain from the Indo-Tibetan marches, was extremely rich in new species. During his twenty years service in India, Prain did not allow administrative duties unduly to

hinder his systematic studies on the flora, and his publication record during this period is most impressive. He had certain preferences, and the family Papaveraceae with the closely associated Fumariaceae engaged much of his attention. Other groups to which he had a predilection were the Scrophulariaceae, Labiatae and Leguminosae. Economic crops also interested him and he made notable contributions on Indian hemp, wheat, the mustards and pulses, and on the species of indigo.

Prain was appointed director of the Royal Botanic Gardens, Kew, on December 15, 1905. He took up his duties at a very difficult period when there was considerable discontent among the staff and much criticism about the state of the Kew publications. Before long he had eased the publication position and won the respect and esteem of his colleagues. As director he soon became immersed in committee work which, alas, is concomitant with the tenure of such responsible office. In spite of his considerable administrative load, Prain applied himself unsparingly to the continuation of his scientific work, and in this he was assisted by wise delegation of duties. He was not a familiar figure in the Gardens, preferring to be guided on horticultural matters by his able curatorial assistants. When he retired in 1922 the staff recorded their thanks "for his consummate tact and patience through years of unparalleled difficulty".

Naturally, with his distinguished record, many honours came his way. He was elected a Fellow of the Royal Society in 1905, president of the Botany Section of the British Association in 1909, president of the South-Eastern Union of Natural History Societies in 1912, and president of the Linnean Society in 1916. He was knighted in 1912 and was also honoured by the King of Sweden and the King of the Belgians. He received the degree of LL.D. from St. Andrews in 1911 and was awarded the Victoria Medal of Honour of the Royal Horticultural Society in 1912 and the Linnean Society's Gold Medal in 1935.

Though on retirement Prain shed his heavy administrative duties and many of the advisory responsibilities linked with the directorship, he readily assumed fresh and important obligations; some, such as membership of the Council of the Zoological Society and appointment as a trustee of the British Museum, seemed somewhat outside his normal interests, but these offices were a tribute to his sound judgment and understanding. The two World Wars dealt harshly with Prain. In the first his only son was killed near Armentières and in the second his home in the Caterham valley was so badly damaged by bombs as to become uninhabitable. After the death of his wife in 1942, his health declined and his appearances in London became rarer. He died on March 16, 1944 (see *Nature*, 153, 426; 1944). Sir David Prain is still remembered with affection and gratitude by some of his former colleagues, happily still working at Kew.

THE NEW RADIO RESEARCH STATION, DITTON PARK, SLOUGH

By Dr. R. L. SMITH-ROSE, C.B.E.
Director

ON June 20, in the presence of a distinguished company, the new and permanent buildings of the Radio Research Station, at Ditton Park, Slough, Buckinghamshire, were opened by Sir Edward Appleton, principal and vice-chancellor of the University of Edinburgh. It was very appropriate that this ceremony should be performed by Sir Edward; first, because he has been very closely associated with the programme of the Radio Research Board for some thirty-six years; and secondly, because it was during his term of office as secretary of the Department of Scientific and Industrial Research that the post-war plans of the Department were drawn up. Among these plans was one which provided for the establishment of a Radio Research Organization which was to absorb and expand the work previously conducted in the Radio Division of the National Physical Laboratory. The plans being followed for this development, and a view of a model of the new building now formally opened, have been described in *Nature* (175, 921; 1955). The present contribution reviews briefly the historical development of the Radio Research Station, and summarizes its present national programme of research as a prominent part of a wider, international range of activities.

Historical

It was realized at the outset that the new organization would require a large area of ground on which to erect its aerial systems and conduct experimental work, in addition to the provision of suitable laboratory buildings for development work and certain types of investigation and measurements. After considering the merits of a number of sites, including some disused airfields and other fields in the vicinity of the new towns being developed around London, it was decided that the new organization should have its headquarters at Ditton Park, near Datchet. In many ways this was a very suitable choice since various types of experimental work had been in progress in these grounds for many years past.

It was after the formation of the Radio Research Board in 1920 that a search was made for a suitable field in which to conduct some experiments on the variation of the direction of propagation of radio waves. As the first chairman of the Board was Admiral of the Fleet Sir Henry Jackson, it was perhaps natural to find that the requirements could be met in the grounds of the Admiralty Compass Observatory in Ditton Park. So a start was made with experiments in radio direction-finding, to which were added, in succession, a study of field strengths from long-wave or low-frequency transmitting stations, investigations in atmospherics, the establishment of an ionospheric observatory, and the study of the modes of propagation of waves of high and very high frequencies.

From 1933 onwards, the Radio Research Station was regarded as an outpost of the Radio Division of the National Physical Laboratory, and while this Division was formally terminated in July 1952, the

association of some of the staff with the National Physical Laboratory has continued in a gradually attenuated form until the new building became ready for occupation a few months ago.

Past Radio Research

In looking back over the past thirty-five years or so, we find that the staff of this station, together with research workers at universities associated with the Radio Research Organization, have made great contributions towards fundamental knowledge of the propagation of radio waves at all frequencies and under all conditions of transmission. A considerable series of publications described the results of the various investigations conducted under the auspices of the Radio Research Board before the Second World War. The work on direction-finding already mentioned was extended to cover a very wide range of frequencies and was applied to the location of the sources of atmospherics as well as of radio transmitters. The demonstration of the use of spaced aerial systems to give the highest attainable accuracy in direction and of the twin-channel amplifier with cathode ray tube presentation has formed the basis of industrial development and its practical application over the past twenty years. A radio sounding balloon was developed, which led up to the present method of sounding the atmosphere for meteorological purposes. In combination with a direction finder for following the course of the free balloons, the direction and speed of winds could be determined.

Intensive research was carried out on the factors which determine the variation of radio field-strength with distance from the transmitter; and the results obtained over a wide range of frequencies have formed the foundation from which has evolved much of the planning of communications, broadcasting and radio navigation services.

At the beginning of the International Geophysical Year, it is appropriate to refer to the Second International Polar Year of 1932–33, when radio was used for the first time as a tool for exploring the physical characteristics of the upper atmosphere. Under the auspices of the Radio Research Board an expedition, including members of the staff of the Station, went to Norway to investigate ionospheric conditions in northern latitudes. It was on their return that the need for regular soundings of the ionosphere became apparent, and there was established at Slough the first ionospheric observatory in the world. From a modest beginning with occasional soundings on special days, there has grown the organization existing to-day, in which a world network of one hundred or more observatories record conditions in the ionosphere at every hour of the day and night. Automatic equipment developed at the Radio Research Station is used at more than twenty of these observatories, six of which are manned by personnel either belonging to, or trained at, the Station. This continuous world-wide study of the ionosphere has provided considerable knowledge used by engineers responsible for the planning and operation of long-distance radio communication and broadcasting services. These services are also assisted by the regular supply of forecasts of the transmission conditions prepared at the Station six months in advance.

All the work referred to so briefly above culminated a few years before the War in the demonstration of the detection at the ground of echoes of radio waves reflected from aircraft. Following this, a group of staff from the Station formed the nucleus of the team which developed the technique of radar up to the stage at which it was taken under the wing of the Air Ministry. This team had the advantage at the outset of being able to apply quickly to a practical objective the techniques of pulse transmission and echo reception, and of direction-finding in both horizontal and vertical planes, which had already been developed for the purpose of fundamental scientific research.

Radio Research

The present programme of the Radio Research Organization is designed to assist in the solution of some of the problems which confront the various users of radio waves and radio-frequency techniques, whether for civil, military or industrial purposes. The major portion of the work for the past few years has been concerned with meeting the needs of the communication, broadcasting and radio navigation services by studying the propagation of radio waves along the ground and through the lower and upper atmospheres, and taking account of the various types of disturbance caused by atmospherics of natural origin and by interference due to electrical equipment. Other portions of the programme include an investigation of the physical properties of certain materials, such as semiconductors and ferromagnetic compounds, which are of special interest in the radio field. The measurement of power and field-strength, particularly in the upper bands of radio frequency, is also the subject of study and development.

Measurements are being made of the speed with which radio waves travel over land and sea, and the results correlated with geological structure and ground conductivity. The effects on wave transmission of irregularities in the ground and the presence of natural or man-made obstacles, such as hills, trees and buildings, are studied with a view of determining, for example, the probable service area of new television stations at increasingly higher frequencies.

The transmission of very short waves to distances beyond the horizon is largely determined by the vertical gradient and regularity of temperature, pressure and humidity in the lower atmosphere or troposphere. A long-term investigation is in progress on the relationship between radio and meteorological conditions in order to obtain the information required in assessing the performance of communication, broadcasting and television services; and especially for the future planning of such services, including radio links, at wave-lengths from a few metres down to a few centimetres.

The Radio Research Station is responsible for the maintenance of six observatories, two in the United Kingdom and four on British territory overseas, which make a continuous study of the characteristics of the ionosphere by the vertical sounding technique. The results obtained at these observatories and at some seventy-five others maintained by other countries are used in the preparation of forecasts of radio transmission conditions all over the world, six months in advance. These forecasts are used on a wide scale by organizations operating broadcasting, communication services and by air and marine navigation authorities.

The technique of sounding the ionosphere has recently been extended to points remote from the observing station by measuring the characteristics of echoes received by a combination of ionospheric

reflexion and back-scattering from the ground at distances up to 10,000 km. (6,000 miles) or more. The study of the nature, time and direction of arrival of such echoes is greatly increasing our knowledge of the manner in which radio waves are transmitted to large distances around the world.

The scope of the various radio services is frequently restricted by the background of noise against which the signals have to be observed. Much of this noise is due to atmospheric disturbances arising in thunderstorms and lightning flashes. Measurements of the intensity of this noise are made in various parts of the world with a uniform type of apparatus designed at the Radio Research Station. The characteristics of this disturbing noise are also under continuous investigation in order to develop means of mitigating its effects. Other apparatus for locating the sources of these atmospheric disturbances has been developed and is used by the Meteorological Office to supply information on the position of storm centres for use in weather forecasting. An equipment for counting lightning flashes is under development in order to assist the meteorologist to supply information on the frequency and distribution of thunderstorms—information which is also required by the radio scientist.

Most of the apparatus required for these and similar investigations is of a highly specialized nature, and has been developed entirely at the Radio Research Station. In some cases, where the equipment is of interest to other users in Britain or abroad, a commercial firm has been assisted in reproducing it. Instances of such manufacture are the ionospheric recording equipment, which is entirely automatic in operation, the cathode ray direction finder for locating sources of atmospherics and the apparatus for measuring the strength of atmospheric noise on high and medium radio-frequencies.

In 1922, Admiral Sir Henry Jackson, chairman of the Radio Research Board, attended the first meeting of the International Scientific Radio Union (U.R.S.I.) in Brussels. In his report to the Board, he stated that all the suggestions which had been worked out in Britain as the basis of future radio research had been accepted internationally. This was the beginning of an association which rapidly developed on an international basis between the staff of the Department of Scientific and Industrial Research employed on radio research and their contemporaries in other countries engaged on similar problems. Many of these problems have involved close collaboration in, for example, the provision of programmes of transmissions, and the standardization of measurements on the ionosphere and of the terminology used in connexion therewith. Sir Edward Appleton attended the next meeting in Washington of the International Scientific Radio Union, of which he was president during 1934–52, and members of the radio staff of the Department of Scientific and Industrial Research have attended all subsequent meetings of the Union, and played a prominent part in promoting international research in scientific radio. At the present time, the writer is a vice-president of the Union, and chairman of Commission II dealing with "Radio and the Troposphere".

In a corresponding manner, the director and staff of the Radio Research Station have for many years past worked in co-operation with the Post Office delegation on the more practical problems studied by the International Radio Consultative Committee (C.C.I.R.), which is a technical advisory body of the International Telecommunications Union. Particularly in the field of radio wave propagation, much of the graphical and other results put forward by Britain have been adopted internationally as the basis for planning new radio communication and other services.

International Geophysical Year

The Radio Research Station is closely connected with the activities of the International Geophysical Year in the fields of the ionosphere and atmosphere. The observatories at Slough, Inverness, Singapore and Port Stanley are being provided with increased staff and facilities for conducting intensive programmes of measurement of heights, critical frequencies, absorption and drift in the ionosphere on the Regular World Days and Special World Intervals associated with the International Geophysical Year. Corresponding observations will also be carried out by a group attached to the Royal Society's expedition to Halley Bay on the Antarctic continent. Measurements of the level, characteristics and direction of arrival of atmospheric noise will be made at Slough, Singapore and Ibadan, Nigeria, where in addition intensive ionospheric observations will be made in co-operation with this Department.

In addition to this direct measurement work, the Radio Research Station has been designated as one of the four world centres for ionospheric and atmospheric noise data. Under this scheme about one hundred observatories associated with the western European nations will send to the Station tabulated and graphical results and also copies of the original ionograms. These will be exchanged with the other world data centres in the United States, U.S.S.R. and Japan, so that each centre will have a complete set of all the observational material obtained during the International Geophysical Year, and will hold this available for supply to research workers in any country in the region. The classification and indexing of the material will be co-ordinated by the secretariat of the International Geophysical Year in Brussels.

Publications and Staff

It has been evident for many years that the publication of papers and reports was not the only means by which the knowledge gained by those associated with the Radio Research Organization is to be made available to those anxious to apply this knowledge. A considerable dissemination is also achieved by the direct contact through committee or individual meetings. But over the years there have been demands for the loan or transfer of members of the staff to other organizations, where they become leaders of small groups or large departments as the case may be. The Radio Research Station has also been used both as a recruiting base and training ground for the staffs of the corresponding radio research organizations in Australia and New Zealand.

During the War, several members of the Department's staff served in succession as radio officers in the British Commonwealth Scientific Office in Washington, and several others have visited both the United States and Canada from time to time on special missions connected with research work of mutual interest to Britain and North America. More recently some members of the staff have been appointed to senior positions in government establishments and in industry in Britain and other

countries. While these movements of staff may be somewhat disturbing to those left behind to continue the research programme, the demand for such experienced men must be regarded as a compliment, and a testimonial to the success of the Radio Research Station.

The scope for research in the field of telecommunications continues to expand, providing problems worthy of study by the ablest physicists and electrical engineers. Many of the techniques developed for the rapid communication of information are equally applicable to line or cable and to radio transmission: and there are many fruitful fields of research in which it is confidently expected that the new organization will play its part in giving direct assistance to trade and industry.

THE NATIONAL PHYSICAL LABORATORY

OPEN DAYS

THE National Physical Laboratory held two open days on May 22 and 23, instead of one as has been its practice for some years. More than two hundred and fifty exhibits, more than half of them new, were on view to 3,600 guests of the Laboratory who came from industry, the universities and government departments.

A problem of particular importance in the design of aircraft is that of instability in flight. The Aerodynamics Division has recently developed a general theory for wings oscillating at any frequency in a subsonic stream. A separate investigation of the aerodynamic forces on control surfaces at low speeds is in progress using the DEUCE high-speed digital computer which has been programmed to carry out the complex calculations. Experiments are under way to establish the theory and to investigate special cases, such as the transonic region, where the theory is inadequate. Equipment developed for measuring the oscillatory forces on model wings with trailing-edge flaps was demonstrated. As the inertial forces are very large compared with the aerodynamic forces, they are balanced against spring reactions in a system excited at its natural frequency by an electrical feedback loop. The direct aerodynamic moments are derived from measurements of driving power and of the change in frequency due to the wind forces, while the lift forces are measured by capacity pick-ups supporting the oscillatory system. Oscillatory pitching and hinge moments have been measured in the subsonic range and the results agree well with theory.

Another aerodynamic oscillatory phenomenon is a type of control-surface oscillation called 'buzz'. Buzz has been experienced on some aircraft at speeds approaching that of sound, and can be so severe that failure of the control surface or its operating mechanism may occur. It is essentially an aerodynamically excited oscillation in a single degree of freedom, the flap vibrating with an angular motion about its hinge against the stiffness of its control circuit, usually with a frequency between 10 and 40 c./s. An experimental apparatus to reproduce buzz and to study the flow conditions in which it occurs was demonstrated in one of the high-speed tunnels. Schlieren investigations have shown that at least one buzz phenomenon starts when separation of the flow at the foot of the shock wave on the upper surface of the aerofoil takes place. High-speed ciné films of the interaction between flow and flap motion have been taken to assist in this study: some of these were on show.

The Control Mechanisms and Electronics Division displayed the new automatic computing engine (ACE) at present under construction. The design of this machine is a result of the experience gained from the ACE pilot model during its four years computing service at the National Physical Laboratory, and from the engineered version of the pilot model, DEUCE, at present in service. ACE will be a much more powerful computing tool than its predecessors because of its increased speed, larger memory and other additional functional facilities. In a typical day's working it will average 20,000 three-address operations per second: its speed is estimated at eight times that of DEUCE. Its large memory store, 1½ million binary digits, will allow very complex problems, hitherto beyond the capabilities of computing machines, to be solved. The new ACE will soon be ready to execute its first test programmes.

The Division demonstrated a new digital plotting table. This has an accuracy of better than 0·01 in., and it plots at the speed of two points a second. It is a very simple design and embodies transistors and printed circuits. It is expected to satisfy an important need for a machine which will plot graphs from digital information on punched cards or punched paper tape.

The Electricity Division demonstrated how the National Physical Laboratory atomic clock is being used to check the drift rates of precision quartz clocks and the variation in the rate of rotation of the Earth. Compared with the atomic clock, the Earth gains in the northern hemisphere summer and loses in the winter, the maximum deviation being 40 milliseconds. Due to improvements in the electronics associated with the atomic clock, frequencies can now be determined with an accuracy of one part in 10^{10} in a measurement lasting only a few minutes. A new atomic clock designed to give even greater reliability, higher accuracy and increased simplicity of operation is under construction.

The most spectacular item on view was the new one-million volt testing transformer. This replaces three air-insulated transformers installed more than thirty years ago. It is a single unit rated at 700 kVA. designed to give a single phase output of one million volts when supplied at 1,200 volts. The winding is oil-immersed in a steel tank, the assembly weighing 55 tons. It is supported from earth on porcelain columns so that the tank can be connected to the centre point of the high-voltage winding—the columns can withstand half a million volts without flashover. The transformer is located in the open air, but the output can be fed into the main high-voltage laboratory through a porcelain wall-bushing 36 ft. long weighing 4 tons (Fig. 1).

The Light Division has collaborated with the Control Mechanisms and Electronics Division to develop a machine-tool monitor. The particular device demonstrated was a screw-cutting lathe controlled from a diffraction grating. A moiré

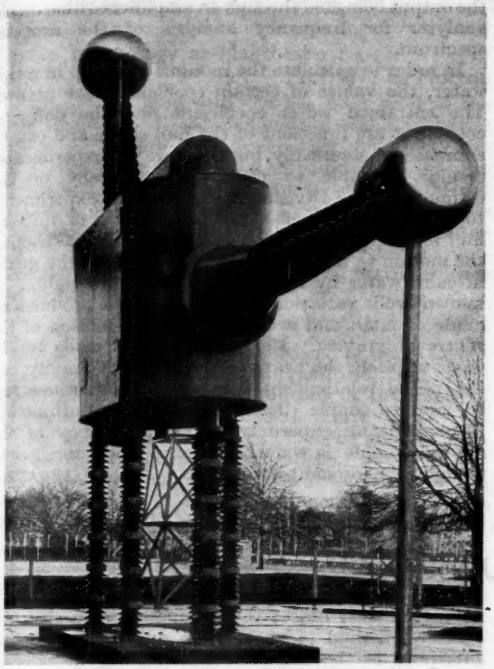

Fig. 1. New one-million volt testing transformer. Crown copyright reserved

system was set up using two diffraction gratings, one fixed and the other attached to the saddle of the lathe. The two gratings were chosen to have the same pitch as the thread being cut, so that one pulse per thread was produced from a phototransistor viewing the moiré pattern. In general the grating would be an integral multiple of the screw pitch. A potentiometer driven by the lathe spindle produced a sawtooth voltage which was sampled by the phototransistor. This sample voltage was obviously a measure of the angle of the lathe spindle at the instant when the pulse occurred. If the thread were perfect, this voltage would be constant; variations in it provided a measure of the errors of the system with micro-inch accuracy. It is intended to use the error signal to move the cutting tool relative to the saddle and so cut a nearly perfect screw thread. If this thread were then used as the lead screw in another monitored lathe, another even better thread could be cut and so on, improving the breed all the time. This is an attractive prospect for the production of machine tools with a new standard of precision.

The Light Division has also developed an automatic recording saccharimeter. This instrument matches two polarized beams using a photomultiplier and employs a Faraday cell as a compensator. The reading is taken off in terms of current and continuously recorded. Having no moving parts, its sensitivity is very high and very short path-length samples can be used.

The Mathematics Division demonstrated some of its powerful computing machines including DEUCE, a differential analyser and punched card equipment.

The Metallurgy Division has continued its research on the mechanical properties of single crystals of iron. The presence of 0·05 per cent nitrogen raises the yield and cleavage strength and increases the likelihood of brittleness, whereas nitrogen in the form of iron nitride has an even greater effect on yield strength and brittleness without affecting the cleavage strength. Using a radioactive technique, it has been found that the concentration of phosphorus at the grain boundaries, in an alloy of iron and 0·09 per cent phosphorus, can be fifty times as great as the grain interior concentration; the grain boundary layer may be thicker than has hitherto been supposed. This work may throw light on the question of temper-brittleness in low-alloy steels.

There have been important developments in micro-focus X-ray diffraction techniques. A new low-angle scattering camera has been built which focuses the X-ray beam by reflexion from two curved mirrors. This is being used to continue the study of progressive changes occurring in the low-angle scattering pattern when the specimen is subjected to increasing amounts of fatigue.

The Metrology Division demonstrated a 1,200-ton compression testing machine. This is to be used in the Division's programme for the development of precision load-measuring devices to extend the National Physical Laboratory standard for compressive loads to 1,000 tons. The new machine is hydraulically operated and can accommodate instruments of a maximum height of 80 in. on a 26 in. square platen. The machine will be used to standardize load-measuring units by building them up from 50-ton units initially standardized in the Laboratory's 50-ton deadweight standard machine.

For the first time the British national copy of the metre was on show. Like the International Prototype Metre, it is a bar of 90/10 platinum–iridium alloy of a special winged *X*-form which exposes the neutral plane and gives optimum rigidity in relation to the weight of the metal used. Last year, by arrangement with the International Bureau of Weights and Measures, it was re-polished and re-ruled with three fiducial lines about 0·005 mm. wide. These are disposed in the neutral plane so that the metre length is represented at both 20° and 0° C.

Following the development of a comparator for measuring the pitch errors of fir-tree root serrations (see *Nature*, **175**, 1102; 1955), a similar device has been produced to measure the pitch errors in the roots of gas turbine disks. The tolerances on pitch are very close, so a high accuracy of measurement is required. The apparatus demonstrated measures to $\pm$ 100 micro-inches ($\pm$ 2·5μ), very rapidly by comparison with a composite slip-gauge standard.

The Physics Division displayed two excellent examples of the application of simple scientific principles to complex problems. One of these was a thermal comparator for the rapid determination of thermal conductivity. This instrument is based on the well-known phenomenon that two substances may feel warm or cold to the touch depending on their thermal conductivities. Two balls are heated, one being pressed against the specimen to be tested. A differential thermocouple system measures the temperature difference between them after ten seconds; by comparison with a known specimen, this figure can be converted directly into thermal conductivity. The readings are affected by the surface finish of the specimens and this effect can be exploited to make the instrument function as a surface finish comparator. The other example of a novel use of a scientific principle was a demonstration of an investigation carried out on a 425-ft. chimney stack. In

order to study its structural damping without having to wait for a suitable wind to excite oscillations, thrust units were attached to the top of the chimney and fired. The vibrations induced were measured in two perpendicular planes by means of piezo-electric accelerometers.

The Division's work on the establishment of standards of high pressure continues, and the new method of eliminating errors due to distortions of the pressure balances has now been used up to 3,000 atmospheres. This technique enables high pressures to be measured to an accuracy of a few parts in 100,000.

The Ship Division has extended its study of the conditions in which cavitation occurs from propellers to other hydrofoil devices like stabilizers and hydrofoil vessels. The Lithgow water tunnel has been modified for this purpose and force and acoustic measurements are now being made in it on a model of a fin for a ship roll-stabilizer. A new three-component balance has been developed and the model is mounted on this. Acoustic measurements are made with a hydrophone placed in a water-filled chamber in contact with a side window of the tunnel, the output being fed through an amplifier to a harmonic analyser for frequency analysis of the acoustic spectrum.

In order to calculate the motions of a ship in rough water, the values of certain coefficients are needed. The entrained water coefficient and the damping coefficient are functions of the hull shape and can be estimated theoretically, but there are few experimental results available to check the accuracy of the estimates. The Division is carrying out experiments to measure these coefficients for a number of different hull forms. The problem is simplified by restricting the motion to one plane and force-pitching the model in calm water by a system of rotating weights. A known cyclic variation of pitching couple produces an angle of pitch and a coupled vertical motion of the centre of gravity. Measurements are made of the angle of pitch, the heave of the centre of gravity and the phase relationship between these motions and the applied couple. These are recorded continuously throughout an experiment. The frequency of the applied couple is variable over a wide range and includes the resonant frequency. A. J. Garratt

OBITUARY

Prof. Marinus Van den Ende

At the time of his death on June 4, at the early age of forty-five, Marinus Van den Ende was professor of bacteriology and dean of the Faculty of Medicine in the University of Cape Town, where he had earlier studied and graduated. He had come to England in 1937 with a John Lucas Walker Studentship, to work in the Department of Pathology at Cambridge, where Prof. H. R. Dean introduced him to me in the autumn of 1938. Even my short talk with him, at that first meeting, had made me glad to be able to respond to a suggestion that he might move to the National Institute for Medical Research, then at Hampstead, for the remainder of his second year.

Early in 1939, when he had been with us there for only three or four months, he had won such high regard from all by his character and personality, as well as by the brilliant promise which he showed in research, that a proposal to keep him, if possible, as a member of our staff was received with general enthusiasm. He felt at that time that his first duty was to South Africa; but he was able to obtain leave to extend his stay with us until the end of that year. In the last week of August the news of the Russo–German pact drove a number of us hurriedly home from the European Continent. Van den Ende had meanwhile married a young lady from South Africa, whom he had met again in London; but I found him now waiting anxiously for my return, in order to offer himself for the position on our staff which he had earlier felt obliged to refuse. He and his young wife had seen clearly what was coming, and both were eager to be with us in the coming world conflict. So he stayed throughout the War, doing splendid service, some of it involving serious personal risk.

Van den Ende first became an active member of a team working on methods for preventing aerial cross-infections in hospitals. Then, with Dr. Christopher Andrewes and the late Dora Lush, he was engaged in researches undertaken with some urgency, and having as their object the production of a safe and effective method of vaccination against typhus—an enterprise in the course of which every member of the team suffered, sooner or later, from an attack of the disease. Later he visited the armies in North Africa, with the rank of major in the R.A.M.C., to make a controlled trial of certain potential chemotherapeutic agents for the treatment of typhus. His final and most distinguished contribution to the war effort was the organization and direction, on behalf of the Medical Research Council and the War Office, of a special research unit, created on the Wellcome Foundation's farm estate at Frant, in Kent, for the production of a vaccine against the very dangerous 'scrub typhus', which the armies had encountered in the jungles of Burma and the Far East.

In 1945 he was free at last to return to Cape Town, where he was appointed professor of bacteriology, and where, in the years that followed, he made a rapidly growing reputation as a coming leader in research on the viruses, and as an influential teacher and an able organizer. He was on a visit to Melbourne some four years ago, to work for six months with Sir Macfarlane Burnet, when signs appeared of the illness which, though its progress was retarded by an operation and other forms of therapy, advanced to its inevitable end. With astonishing courage he used the intervals of temporary relief, between successive courses of prostrating treatment, to carry on his researches and his teaching, to such effect that his reputation in the world as a virologist continued still to grow, while he was persuaded further to accept the duties of dean.

Looking at what Van den Ende had thus achieved in a life cut short so early, and so marred by illness in what should have been its crowning years, his friends are left wondering what heights he might have attained had fate been kind, and mourning the loss to the world and to the community of science. Their sympathy goes to his widow, facing the situation with a courage worthy of him, and to their four children. H. H. Dale

NEWS and VIEWS

Textile Technology at Manchester : Prof. W. E. Morton

PROF. W. E. MORTON, who has been head of the Department of Textile Industries at Manchester College of Science and Technology for thirty-one years, has been appointed vice-principal of the College and Arkwright professor of textiles, and will be taking up his duties at the beginning of the Michaelmas term. In November he is to receive the Warner Medal of the Textile Institute for his outstanding publications in the field of textile science and technology.

Prof. J. J. Vincent

MR. J. J. VINCENT, at present head of the Weaving Department at the Shirley Institute, has been appointed to succeed Prof. Morton in the chair of textile technology at the Manchester College of Science and Technology. Mr. Vincent graduated in mathematics at University College, London, and after obtaining his M.Sc., joined the staff of the Shirley Institute in 1929. During the War he was engaged in operational research for the R.A.F. and for a time was head of the Operational Research Section of Transport Command. In 1945 he returned to the Shirley Institute as head of the Weaving Department. He was made a fellow of the Textile Institute in 1950. When he started to work at the Shirley Institute, Mr. Vincent had the ambition to turn the design and setting of the loom from a craft to a science by applying mechanical principles and ideas underlying all engineering, and this idea can be seen in all his work. He has written papers, both alone and in association with others, on shuttle velocity, and under his influence 'systematic loom overlooking' has become a realized fact. In recent years, not only has he performed all the duties involved in the running of a large research department, but he has also contributed in detail to recent far-reaching developments that have occurred in the equipment for and the techniques of warp sizing—notably in the development of the 'Shirley' automatic size box and the use of sizing slurries. It can be confidently expected that under Mr. Vincent's direction textiles at the Manchester College of Science and Technology will continue to progress both as a science and as a technology.

Anatomy at Emory University, Georgia : Dr. G. H. Bourne

DR. GEOFFREY BOURNE, reader in histology in the London Hospital Medical College since 1947, has been appointed professor of anatomy in Emory University, Georgia. He entered the University of Western Australia in 1928, studying comparative anatomy and histology, and soon turned his attention to the mammalian adrenal gland, on which he made a wide comparative and histochemical study. It was on this organ that he developed a histochemical technique for demonstrating vitamin C in tissues. Appointments in Australia included biologist in charge of experimental work, Australian Institute of Anatomy (1935), and the making of a survey for the Commonwealth Government of the nutritional value of Australian food (1937). Earlier, he had worked for a year in Melbourne under Prof. F. Wood-Jones.

A Beit Memorial fellowship took him to Oxford in 1938, where he was demonstrator in physiology (histology) and also held a Mackenzie Mackinnon research fellowship. During the latter part of the Second World War he was in charge of development of rations and physiological problems for Special Forces, South-East Asia. Later, with the rank of lieutenant-colonel, he was nutrition advisor to the British Military Administration, Malaya. He returned to Oxford in 1946 to continue research on wound healing and on localization of enzymes, particularly phosphatases, in hard and soft tissues. He has edited and written a number of books, "Cytology and Cell Physiology" (1942) and "Biochemistry and Physiology of Bone" (1956) being the best known. He will be chairman of the Anatomy Department at Emory University.

U.S. National Science Foundation : Dr. E. A. Eckhardt

DR. ENGLEHARDT AUGUST ECKHARDT, formerly vice-president in charge of research for the Gulf Research and Development Co., Pittsburgh, Pennsylvania, has been appointed assistant director of the National Science Foundation, for the Division of Mathematical, Physical and Engineering Sciences. Raymond J. Seeger, who has filled the position in an acting capacity, will continue as deputy assistant director for the Division.

A physicist, Dr. Eckhardt is well known for his work in geophysics, ballistic measurements and building acoustics. He was born in Cedarburg, Wisconsin, and received his bachelor's and doctor's degrees in physics from the University of Pennsylvania. During 1908–17 he served as lecturer and assistant professor of physics at the University of Pennsylvania, except for a period during 1912–13, when he was awarded the Harrison fellowship from Pennsylvania to study at the University of Göttingen. Dr. Eckhardt was employed during 1917–25 as physicist in the Bureau of Standards. In 1925 he became assistant chief of the Research Department, Marland Oil Co., until 1928, when he joined the Gulf Research and Development Co. as assistant director of research, serving as vice-president from 1941 until 1953. During the Second World War Dr. Eckhardt served as deputy chief of the Physics Division and chief of its instruments section in the Office of Scientific Research and Development. Since 1954 he has been a consultant for the Gulf Company. Dr. Eckhardt was president of the Society of Exploration Geophysicists in 1939 and vice-president of the Geological Society of America in 1953.

British National Committee for Non-Destructive Testing

IN recent years the subject of the non-destructive testing of materials has achieved great importance, and at the beginning of 1957 a combined appeal was made by a number of societies to the Joint Committee on Materials and their Testing to foster the establishment of a National Committee to act as a focus in the United Kingdom for interest in the principles and techniques of non-destructive testing. The Joint Committee accordingly set up a sub-committee to examine this request and, as a result of its recommendations, the Joint Committee has approved the constitution, terms of reference and rules for a committee which will be known as the British National Committee for Non-destructive Testing. Membership of the British National Committee is open to institutions or societies with an interest in non-destructive

testing: the subscription is 5 guineas per annum. Each member society will be asked to nominate a representative who would take part in meetings of the Committee. Applications, for the time being, should be made to the secretary of the Joint Committee on Materials and their Testing, Mr. R. Main, at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1.

Society of Instrument Technology

The Society of Instrument Technology is setting up a special section devoted to data-processing systems. This section will hold its first meeting in London on October 10, when a paper on "A System for Handling Wind-Tunnel Data" will be presented by J. F. M. Scholes, of the Royal Aircraft Establishment, Bedford. Further meetings will be held on November 14 ("A Digital Plotting Table", by J. Morrison, of Dobbie, McInnes, Ltd.); January 28 ("Digital Codes and Coding", by M. P. Atkinson, of the National Physical Laboratory); and on April 29, when a joint meeting on "Scanning and Logging", with papers by D. H. Whiting and J. Dunkley, of Imperial Chemical Industries, and J. Churchill, of Sunvic Controls, Ltd., has been arranged.

Initial emphasis will be on systems for handling experimental data, and for industrial monitoring and control. The section will be concerned with system design as well as with the detailed design of equipment; it will also deal with the use and organization of systems and with design-study work. The literature on data-processing techniques and application is scattered and much existing knowledge remains unpublished; one of the section's first tasks will be to obtain papers that review the present stage of development, for publication in the quarterly *Transactions* of the Society. Membership of the section is open to all members of the Society, who may also join the other special group, the Control Section. Further information can be obtained from the Secretary, Society of Instrument Technology, 20 Queen Anne Street, London, W.1. The secretary of the Data-Processing Section is Mr. W. T. Bane, 137 Kenilworth Court, London, S.W.15.

Australian Biochemical Society

The Australian Biochemical Society was founded in 1955 under the presidency of Dr. M. R. Lemberg. Its objects are simply the advancement of the science of biochemistry. The first annual conference was held in Sydney in 1956. At the second conference, held at the University of Melbourne during June 5–8, one hundred and fifty members from all parts of Australia attended, and the fifty-three papers presented evoked stimulating discussion. The papers covered a wide variety of topics; the general quality of the work indicated that Australia has undoubtedly kept pace with modern developments and is, in fact, among the leaders in some important fields of biochemistry. University, government, industrial and independent research institutions were well represented in the list of original contributors. A special evening lecture entitled "Phenyl Thiohydantoins in Protein Analysis" was given by Dr. Pehr Edman, formerly of the University of Lund, Sweden, and recently appointed John Holt director of biochemical research at St. Vincent's School of Medical Research, Melbourne. Another evening session was devoted to a general discussion on the role of the clinical biochemist and the organization of biochemistry in hospitals. Prof. V. M. Trikojus, Melbourne, was re-elected president for 1957–58.

Finance for Research on Wool

In the debate in the House of Commons on July 11, when the Draft Wool Textile Industry (Export Promotion Levy) Order, 1957, and the Draft Wool Textile Industry (Scientific Research Levy) Order, 1957, were approved, the Parliamentary Secretary to the Board of Trade, Mr. F. J. Erroll, explained that the purpose of the latter Order was to increase the yield of the research levy from about £155,000 to about £200,000; it is also intended to make some minor changes in the range of persons liable to pay the levy in order to bring it more into accord with present conditions and current developments in the industry. Mr. Erroll said that the additional money is required for capital expenditure by the Wool Industry Research Association and to meet increased costs since the levy was introduced; further, the Wool Textile Research Council also wishes to increase its research grants. In welcoming the two Orders, Mr. H. Rhodes expressed the opinion that methods of research used in the textile industry need re-casting and that there is too much duplication of effort. Research associations, he said, are spending small amounts on the same work because there is not enough liaison. He suggested that the original conception of research, as outlined when the Department of Scientific and Industrial Research was established, is now obsolete and that there is too much complacency. Problems common to the whole range of the textile industry should be investigated in one place with adequate resources, and the research stations should continue their day-to-day work for the firms they serve.

"Chymia"

The publication of "Chymia", an annual devoted to the history of chemistry, will be resumed in the spring of 1958 with Vol. 5. The publication is now sponsored jointly by the Edgar Fahs Smith Collection of the University of Pennsylvania and the Division of the History of Chemistry of the American Chemical Society. The editor-in-chief is Henry M. Leicester, College of Physicians and Surgeons, San Francisco, California, to whom all articles for publication, which must be in English, should be submitted.

University Interchange

The British Council has issued a report on "University Interchange between the United Kingdom and other European Countries, 1948–56" (pp. 56. London: The British Council, 1957). The report traces the development of certain schemes which the United Kingdom has undertaken in order to foster interchange visits between members of British universities and those of other European countries. Among these is the scheme for arranging short visits for university teachers; during the period under review 580 visits were received from foreign scholars, while 405 members of British universities went overseas. More than one-quarter of these were from the University of London; the four Colleges of the University of Wales sent one between them. So that interchange would not take place merely between scholars of established reputation, provision has been made to enable young workers engaged in original research to visit colleagues engaged in similar work in other countries. At present this scheme involves inter-

change between the universities in the United Kingdom, Belgium, France, Germany and Yugoslavia; it is hoped to include other countries in the scheme very shortly. Of the twenty-four British research workers who visited European universities one-sixth were from Oxford; not one came from Sheffield, Manchester, Liverpool or Edinburgh. The report also contains details of arrangements for longer teaching visits which are to begin in the academic session 1957–58, postgraduate scholarships, and the various awards by international bodies.

Marshall Aid Commemoration Commission

THE third annual report of the Marshall Aid Commemoration Commission (pp. 8. Cmnd. 167. London: H.M. Stationery Office, 1957. 6*d*. net) covers the year ended September 30, 1956, the first academic year in which a full quota of Marshall Scholars consisting of two groups selected in 1954 and in 1955 have been living in the United Kingdom. The work of the Commission has been directed mainly to making the best arrangements possible to enable these students to proceed with their studies and to selecting a further group of scholars to take up courses in British universities in October 1956. A list of these twelve scholars-elect is included in the report. Of the twelve scholars selected for the original awards, seven completed their tenure at the end of the academic year 1955–56, and of these two gained a Ph.D., one an M.Sc.(Econ.) and three a B.A. (one with first-class and two with second-class honours). The one who failed to graduate is being allowed to submit his M.A. thesis in a revised form at a later date, and the remaining four are to continue as students in British universities in 1956–57, three with extensions of their scholarships by the Commission. The remaining scholar had to resign his award for family reasons at the end of his first year. The Commission, while arranging for the proper reception of each group of scholars arriving in Britain, has not felt it necessary or desirable to organize an 'orientation programme' for the party as a whole, but has sought to encourage the newcomers to settle in as soon as possible at their several universities. The Commission acknowledges with gratitude the offers of hospitality to Marshall Scholars by various bodies, such as the English-Speaking Union and the Dominions Fellowship Trust. The Commission is studying the problem of payment of fares of candidates summoned for interviews, with the view of finding some solution which will not upset the distribution of awards between different areas in the United States, but which may prove less expensive in travel costs than the present system. All applicants continue to express strong preference for the Universities of Cambridge, London and Oxford, and in future they will be required to state a second preference elsewhere.

Fresh Water from Salt Water

PRESENT methods of and future prospects for preparing fresh from salt water have been reviewed by D. Neville-Jones, of the Department of Scientific and Industrial Research (*Colonial Plant and Animal Products*, 6, No. 1; 1956). In the near future there is every prospect that electrodialysis will prove the cheapest process for preparing fresh water from salt waters containing four or five thousand, and possibly eight or nine thousand, parts per million of salt. For waters containing more salt than this, and particularly with sea water, some form of distillation remains the only process which can at present be offered with confidence. In an area of high fuel cost, where a compact and self-contained plant is required, the choice would probably lie with vapour compression distillation. Solar distillation may be useful for the provision of small quantities of drinking water in isolated areas of high fuel cost where sunshine is fairly abundant.

Hydraulics Research

SEVENTY years ago Osborne Reynolds was conducting his classical experiments into the behaviour of models of tidal estuaries. Ten years later the first permanent river hydraulics laboratory was set up at Dresden. This was followed by a series of other large laboratories in Germany, the United States, India and Holland. Just after the Second World War, Britain was the only major country which practised hydraulic engineering on a large scale with no adequate laboratory as judged by international standards. In spite of this, valuable work was done, notably at the University of Manchester and the Imperial College of Science and Technology, London. In 1946 a Hydraulic Research Board was set up to organize work on loose boundary hydraulics on a national scale. A site for a laboratory was acquired at Howbery Park, Wallingford, in 1949 and was partially occupied in 1951. This laboratory, the Hydraulics Research Station of the Department of Scientific and Industrial Research, came into full use at its present stage of development last year. This point in the progress of the Station was marked by a visit by H.M. the Queen in November 1956.

The work of the Station during 1956 is recorded in its annual report, "Hydraulics Research 1956" (Report of the Hydraulics Research Board with the Report of the Director of Hydraulics Research. Pp. vi+54+12 plates. London: H.M. Stationery Office, 1957. 4*s*. 6*d*. net). Although the Station was intended for the study of loose boundary hydraulics, it has, in fact, undertaken work connected with other branches of civil engineering. Such work includes the action of sea waves on walls and in harbours, flood-relief schemes and testing of spillway designs. Roughly one-fifth of the effort of the Station is devoted to background research. This is partly exploratory work into loose boundary problems, such as the action of sea waves in scouring and silting beaches, and partly basic research, much of which is done in conjunction with university departments.

Citrus Fruits in Assam

CULTIVATED and wild forms of citrus have been known in Assam from ancient times; indeed, their abundance and diversity are such as to suggest that this region may have been a centre of origin and dispersal of some of the species and varieties. Under the auspices of the Indian Council of Agricultural Research, S. C. Bhattacharya and S. Dutta have produced a comprehensive monograph, with many excellent plates in colour, entitled a "Classification of Citrus Fruits of Assam" (Indian Council of Agricultural Research. Scientific Monograph No. 20. Pp. vi+110+84 plates. Delhi: Manager of Publications, 1956. Rs. 34; 52*s*.). Like other workers in this field, the authors have recognized the acute nomenclatural difficulties and the need for more systematic and other work, the more so as natural cross-pollination has resulted in the production of new forms adapted to the varied environments which the region affords. The present work is based on

extensive collections, on long and intimate personal experience on the part of the authors of all the major citrus-growing areas in the hills and on the plains, together with wild specimens from the forest tracts, and on the creation and maintenance of a living museum of specimens, the latter affording materials for detailed studies. The classification adopted is based on standard treatises, but it has been broadened to accommodate the abundant materials found in Assam and, at this stage, is admittedly empirical. In all, some sixteen main species are enumerated.

Transmission of Raspberry Mosaic Viruses to the Strawberry

The disease known as raspberry mosaic is caused by a combination of two viruses, referred to as rubus yellow-net and black raspberry necrosis. In a recent study, R. Stace-Smith and F. C. Mellor (*Canadian J. Bot.*, 35, 287; 1957) have attempted, by means of the leaf-grafting technique, to transmit the two component viruses of raspberry mosaic, separately and in combination, to three strains of *Fragaria vesca* L. Only the rubus yellow-net virus was transmitted to the strawberry and it induced severe symptoms. Neither the raspberry aphid, *Amphorophora rubi* Kalt., nor the strawberry aphid *Pentatrichopus fragaefolii* (Ckll.), transmitted the yellow-net virus from raspberry to strawberry, although *A. rubi* was able to transmit the virus from strawberry back to raspberry.

Scientific Instrument Manufacturers' Association : Officers

Mr. P. Goudime, managing director of Electronic Instruments, Ltd., has recently been elected president of the Scientific Instrument Manufacturers' Association for the year 1957–58, in succession to Mr. G. A. Whipple, chairman and managing director of Hilger and Watts, Ltd., who now becomes a vice-president. Mr. R. Barrington Brock, director of Townson and Mercer, Ltd., has been elected vice-president (president-elect). Other officers for 1957–58 are: *Hon. Secretary*, Mr. L. A. Woodhead (Cossor Instruments, Ltd.); *Hon. Treasurer*, Mr. P. J. Ellis (R. B. Pullin and Co., Ltd.). Representing Sections of the Association are the following new members of the Council: Optical, Mr. G. C. Ottway (W. Ottway and Co., Ltd.), Mr. P. D. Scott Maxwell (Cooke, Troughton and Simms, Ltd.); Surveying and Navigational, Mr. R. Broadbent (Sperry Gyroscope Co., Ltd.); Electronic, Mr. A. W. Jones (Fleming Radio (Developments), Ltd.); Nucleonic, Mr. H. A. Luss (Isotope Developments, Ltd.); Northern Area, Mr. A. Howarth (Fielden Electronics, Ltd.).

The Night Sky in August

Full moon occurs on August 10d. 13h. 08m. U.T., and new moon on August 25d. 11h. 32m. The following conjunctions with the Moon take place: Aug. 4d. 21h., Saturn 0·2° S.; Aug. 27d. 17h., Jupiter 5° N.; Aug. 28d. 01h., Venus 3° N. In addition to these conjunctions with the Moon, Mars is in conjunction with Regulus on Aug. 6d. 15h., Mars being 0·7° N., and Venus with Jupiter on Aug. 22d. 15h., Venus being 0·5° S. Mercury is too close to the Sun for observation during the month. Venus sets about an hour after the Sun, and will be visible as a bright object low in the west just after sunset. Mars and Jupiter are too close to the Sun for observation. Saturn sets at 23h. 55m., 23h. 00m. and 22h. 00m. on August 1, 15 and 31, respectively; it is stationary on August 12, and afterwards moves eastwards among the stars. The stellar magnitude of Saturn is + 0·7 and its distance from the Earth on August 15 is 900 million miles. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Aug. 5d. 20h. 13·9m., ξ Oph. (*D*); Aug. 6d. 20h. 33·9m., 15 Sgr. (*D*); Aug. 19d. 2h. 42·5m., 163 B. Tau. (*R*). *D* and *R* refer to disappearance and reappearance, respectively. The Perseid meteors are active during the first two weeks of August, but conditions are very unfavourable for observation.

Announcements

Dr. D. T. A. Townend, director-general of the British Coal Utilization Research Association, and Dr. A. C. Monkhouse, acting director of fuel research in the Department of Scientific and Industrial Research, have been appointed to the Fuel Efficiency Advisory Committee in succession to the late Dr. G. E. Foxwell and Mr. W. L. Boon.

Dr. William Railston, a principal lecturer in physics at the Royal Military College of Science, Shrivenham, is to be seconded as scientific and technical adviser to the Commonwealth Relations Office with special responsibility for the scientific problems of the Colombo Plan. The appointment is for eighteen months. He will be based in London, but will make visits to India, Pakistan, Ceylon and other eastern countries.

A special one-day course on "Safety and Health in Welding", intended for nurses in industry and safety officers, has been organized by the Institute of Welding, to be held in London on October 12. Inquiries should be addressed to the Secretary, Institute of Welding, 54 Princes Gate, London, S.W.7.

A Faraday Society Discussion on "Interaction in Ionic Solutions" is to be held in the University Laboratory of Physiology, South Parks Road, Oxford, during September 17–19. There will be three sessions, devoted to the general theory of electrolytes, incomplete dissociation, and ion-solvent interaction, respectively. All inquiries should be addressed to the Assistant Secretary, Faraday Society, 6 Gray's Inn Square, London, W.C.1.

The eighth Conference of the Medical Group of the Institute of British Photographers will be held at the Royal Infirmary, Manchester, during September 20–22. It will be opened by Mr. Robert Newell, dean of Postgraduate Medical Studies, Manchester. This Conference is open to anyone interested in medical illustration. Full details can be obtained from the Medical Secretary, Institute of British Photographers, 38 Bedford Square, W.C.1.

The Universities Federation for Animal Welfare is organizing a Summer School designed for undergraduates of all faculties, to be held at Westham House, Barford, Warwick, during September 14–21. The programme will include visits to a bacon factory, an artificial insemination centre, and the animal house of a medical laboratory, with talks, discussions and films on animal welfare problems in Australia, New Zealand, Nigeria and Germany, the supply of laboratory animals, humane pest control, the training of guide dogs for the blind, humane technique in the laboratory, and slaughtering problems. All inquiries and applications to attend should be sent to Miss M. P. Williams, Universities Federation for Animal Welfare, 7a Lamb's Conduit Passage, London, W.C.1.

A UNIVERSITY COURSE IN ARTS AND SCIENCE

THE General Board of the Faculties of the University of Cambridge has prepared a report outlining a course whereby students could undertake study of a science subject as well as of an arts subject. At present no firm recommendations have been made to the University; none will be made by the General Board until the Senate has had the opportunity of discussing the important new questions of educational policy raised by the proposals.

The case for a new university course combining science and arts subjects is persuasively argued in the report. It is well known that a large number of graduates do not make direct use, after they leave their university, of the specialized knowledge they have acquired during their undergraduate days. For many such students it is the nature of the education they receive at the university, rather than the content of their courses, which is important; in the wide range of posts which they may be expected to occupy in national and local government, industry and other fields, the factual knowledge which they have acquired at the university will be of less value than the way in which they have been trained to think. The Board considers that although the majority of such non-specialist students will continue to profit from existing courses either in the arts or in the sciences, there are others who would benefit greatly from an opportunity to study both an arts subject and a science subject at the university.

The new course would give students the advantages of training in both arts and science. Arts men are trained not only to collect accurate data and to use them systematically, but also to exercise critical judgment upon matters of opinion where scholars may reach quite different conclusions. On the other hand, the conclusions of the scientist are based on precise observations and measurements, involve exact calculations, and must be tested by experiment or controlled observation; agreement on essential issues can therefore ultimately be reached. With this distinction in mind, the Board thinks the time is opportune for a new scheme, within the Cambridge Tripos system, designed to give undergraduates an opportunity of undergoing both types of discipline, and of learning to appreciate the advantages and limitations of both. The purpose of the scheme is to provide a course that is specially planned for the undergraduate who knows at the outset of his university career that he does not wish to specialize in science, but who nevertheless wishes to gain a measure of insight into the aims and methods of science.

Although the Board's recommendations are based primarily on the scholarly and intellectual merits of the proposed combination of arts and science subjects, it considers that such a combination would have other, secondary, advantages. Those who took the course as a preparation for an administrative career in which they would most probably have to deal with specialist scientists and to make judgments on scientific matters would be better equipped for their work through having made some study both of the humanities and of scientific method and thought. If Cambridge were to provide the kind of course recommended, it might encourage some schools to establish corresponding combined courses in their sixth forms.

The course recommended by the Board would include one specially designed in science, extending over three terms and the preceding long vacation, which could either precede or follow a two-year course for a part of an existing Tripos in an arts subject. In making this suggestion, the Board emphasizes that it considers it to be the most practicable suggestion at the present time, and not necessarily the ideal course or the only course that might eventually be adopted by the University. It also emphasizes that the proposed course is not intended to train persons who could in any way be regarded as substitutes for qualified scientists. The Board realizes that, at the present time, when the demand for trained scientists is constantly increasing, most of those who have specialized in scientific subjects at school will not wish to take a course combining arts and science. It has based its reasoning on the assumption that the greatest need is likely to be for a course in science specially designed for those who have studied arts subjects at school.

Since the aim of the specially designed course would be to teach science as part of a general education, the emphasis would be on those aspects of science which were of importance to students who did not intend to become practising scientists; the parts of science to be particularly stressed should be concerned with methods of thought which are, so far as possible, different from those used in the humanities.

The course would be planned to study a comparatively narrow branch of science in considerable depth in such a way as to bring out the intellectual content of the subject. The acquisition of some detailed scientific knowledge would be second in importance to learning about the methods of investigation and the methods of thought employed in science. The subject selected for study should be a branch of science which is advancing at the present day and which has wide applications. Researches in it should have been in progress long enough for interesting lessons to be drawn from studying its advances. It should involve some exacting processes of thought, if possible with wider philosophical implications; mathematics should be used little in its presentation.

To begin with, the course recommended is one dealing with radioactivity and the atomic nucleus; a course of lectures lasting one academic year, together with a preliminary course of five and a half weeks in the preceding long vacation, could be so planned as to provide a scholarly study of that branch of physics suitable for undergraduates who had obtained honours in an arts Tripos, and leading up to an examination at honours level. The Board hopes that it may eventually be possible to institute a course illustrating the aims and methods of the biological sciences, possibly on some such topic as 'evolution', which would range over several fundamental sciences.

The Board has considered whether some kind of qualifying examination should be held at any early stage of the science course so as to ensure that the

course would only be taken by students who were likely to be able to cope with it; it believes that it would be impracticable to set a formal examination soon enough to fulfil this purpose, but it should be possible for the persons responsible for the teaching for the course to devise tests which would enable them to advise tutors at the end of the proposed preliminary long vacation course whether their students were likely to complete the full course satisfactorily.

Practical classes designed to teach techniques to future specialist scientists would not be appropriate in this kind of course. Instead there would be lecture demonstration experiments designed to exhibit phenomena, and whenever possible the students would be encouraged to manipulate these themselves, and sometimes to take numerical readings for the purpose of demonstrating some quantitative law. A few simple quantitative experiments would be performed by the students, and they would be asked to explain the results. The emphasis would be on the explanation and not on the taking of the observations. The total time spent on practical work would be comparatively small.

The proposed course would be of honours standard; students of good quality should be attracted to the course so that potential employers shall be persuaded that the course is a serious one and not a 'soft option'. To this end the Board proposes that the examination to be held at the end of the proposed one-year course in science should be a Tripos examination; any other name would predestine the experiment to failure.

The Board considers that the teaching for the proposed course should be given by experienced University teaching officers from the appropriate department who are actively engaged in work in their own subject and who wish to take part in this particular experiment; some or all of the normal teaching programme of those who take part in the proposed special course should be taken over by one or more University demonstrators who would be specially appointed for this purpose.

VEGETABLE QUALITY

THE Second International Colloquium on Vegetable Quality was held in the Conservatoire des Arts et Métiers, Paris, during April 24–27. It was organized under the auspices of the Confoederatio Internationalis ad Qualitates Plantarum Edulium Perquirendas, the membership of which comprises those interested in the genetics, biochemistry, physiology, ecology, culture and preparation of edible, and medicinally used, plants. The first colloquium, which had been held in Geisenheim am Rhein in 1955, had not attracted such an international interest as the second colloquium, which had an attendance of about one hundred specialists, including German, Italian, Polish, Russian, British and American workers.

After the visitors had been welcomed by Profs. E. Terroine and J. Dufrénoy (Paris) and Prof. L. Genevois (Bordeaux), Prof. W. Schuphan (Geisenheim) opened the colloquium and outlined the various fields of study of vegetable quality. Quality is the sum of the biochemical properties of the plant and may conveniently be classified under the three headings of external features, suitability, and nutritional factors. Prof. Schuphan stressed the importance of obtaining a correlation between the biological values of nutritionally important compounds and their chemical analyses. The life and work of Prof. A. Scheunert, former director of the Vitamin Institute at Potsdam-Rehbrücke, was commemorated by Prof. Schuphan, while an address on Prof. A. Chevalier, founder of the Colonial Agronomy Laboratory of the Museum of Natural History, was delivered by Prof. M. Portères, the present director of the Laboratory.

Forty-eight papers were presented. As it is not possible to summarize all adequately, an attempt will be made to present an impression of the general trends in the various sessions.

Since vegetable protein is the major protein intake in the unsophisticated diets of the bulk of the world population, it was natural that in the session on proteins and amino-acids the major concern should be with nutritional quality, especially with regard to content of essential amino-acids, of vegetable protein. Prof. Schuphan presented two papers on the analysis of essential amino-acids in the *Brassica* family and the influence of genetical factors on the amino-acid composition; ten different *Brassica* spp. show a wide range of biological activities. Dr. W. Postel (Geisenheim), in a paper on the effect of manuring on the essential amino-acid composition of potatoes, showed that, above an optimal concentration of nitrogen in the soil, there was a decrease in the biological activity of the protein in the potato; it was suggested in discussion that this may have been caused by a lack of carbon for synthesis of these amino-acids. Dr. V. L. Kretovitch (Bach Institute, Moscow) described his work on the biosynthesis of amino-acids in plants, most of which are synthesized by transamination of the appropriate keto-acids. However, tryptophan synthesis is stimulated by the addition of indole, serine and anthranilic acid. Asparagine and glutamine are apparently formed directly in the protein by amination of aspartic and glutamic acids, respectively. Mlle. M. L. Champigny (Gif) discussed the formation of amino-acids during photosynthesis in Crassulaceae. Aspartic and glutamic acids and alanine, which are derived from Krebs cycle keto-acids, are formed first. However, on long exposures to light the alanine concentration diminishes and that of serine is increased. Mlle. Champigny also described how the amino-acid composition of *Chlorella* proteins varies according to whether urea or potassium nitrate is used as nitrogen source. Using potassium nitrate as compared with urea increases the concentrations of aspartic and glutamic acids but the concentrations of serine and glycine decrease. The microbiological determination of tyrosine, tryptophan, methionine and lysine directly in plant proteins was discussed by Prof. Genevois and Dr. J. Baraud (Bordeaux).

The session on vitamin C was devoted to discussions on the methods of determination of vitamin C and a comparison of the vitamin C content of both European and tropical seed and stone fruits, especially in relation to the satisfaction of nutritional requirements for vitamin C by such foods.

Two complementary papers on the biosynthesis of carotenoids were given by Dr. T. W. Goodwin (Liverpool) and Prof. G. Mackinney (Berkeley, California). Dr. Goodwin discussed mainly the structures and metabolism of compounds which might be precursors of the C_5-repeating unit which is the basis of the C_{40}-skeleton of the carotenoids. The

pathway of synthesis of this C_{40}-compound is possibly similar to that of cholesterol in animal tissues; it may involve condensation of eight C_6-acids to give a C_{48}-compound which by six simultaneous decarboxylations gives the C_{40}-skeleton. Prof. Mackinney's researches using leucine labelled with carbon-14 indicate that C_4 of leucine is specifically incorporated into carotene by *Phycomyces blakesleeanus*, suggesting that leucine may form an *iso*-C_5 unit which is incorporated into a carotenoid precursor *in toto*. Extended genetical studies in tomatoes suggest that the Porter–Lincoln series is not operative, but that the aliphatic and alicyclic carotenoids are formed in parallel from the same common precursor. Dr. M. Signol (Paris) reported the effect of tetronic acid on the pigmentation of maize seedlings. Paper chromatography shows an increase in the carotenoid hydrocarbon fraction with a disappearance in xanthophylls, chlorophyll and phæophytin; by column chromatography it was found that the major hydrocarbons were now lycopene and γ-carotene.

During the session devoted to the B vitamins and vitamin E, the oxidation of tocopherols in oils from maize and rice was discussed by Dr. G. Zwingelstein (Lyon); the tocopherols in rice are more stable than those in maize under comparable storage conditions; thus, although initially maize has a higher tocopherol concentration, this rapidly drops to a level below that in rice. Mlle. N. Vokral (Paris), discussing the biogenesis of riboflavin by *Aspergillus niger*, showed that it was dependent upon the magnesium concentration of the culture medium; for example, high magnesium concentrations inhibit flavin synthesis.

Aspects of vegetable quality other than nutritional were discussed in the session on tannins and polyphenols.

In a review of anthocyanins and polyphenols (communicated), Dr. E. C. Bate-Smith (Cambridge) dealt with their relationship to appearance, flavour and texture, and described new types of those compounds which had recently been isolated from plants. Appearance and flavour of such processed vegetable products as tea and cocoa were closely connected with the polyphenol content; desirable cocoa flavour is only obtained in a cocoa bean which has been so fermented that the purple anthocyanin colour has been replaced by a brown colour of phenolic oxidation products. 'Stringiness' in beans has always been associated with lignin deposition, but recent results have indicated also the participation of leucoanthocyanins, which are deposited during cell-wall lignification. Soluble leucoanthocyanins are responsible for hazes, sediments and 'body' of alcoholic beverages. The occurrence and identification of catechins, gallocatechins and their gallates in tea, quinic and shikimic acids in apples and *p*-coumaroyl quinic acid in *Antirrhinum* were the subjects of papers by Academician A. I. Oparin (Bach Institute, Moscow), Dr. A. C. Hulme (Ditton) and Dr. H. Böhme (Berlin), respectively. Prof. J. Masquelier (Bordeaux) described the bactericidal action of certain wines which is associated with the pigmented fraction from which the sugar and the alcohol have been removed. Prof. J. Lavollay (Paris) described experiments on the coupled destruction of ascorbic acid by the action of phenolase on certain ortho-dihydroxy flavonoids. The destructive activity does not depend solely on the presence of ortho-dihydroxy groups since phloretin and naringenin, which do not contain such groupings, are very active. Flavonoids such as quercetin are more active as aglycones, the glycosides quercitrin and rutin being almost inactive.

In the session on mineral nutrition, Dr. D. Bertrand (Paris) gave a comprehensive review of metal enzyme systems; other papers were on the influence of mineral elements on plant growth and the effect of minerals in wheat on flour quality (Dr. W. Morgulis, Toulouse).

The proceedings of the colloquium will be published in Vol. 3 of "Qualitas Plantarum et Materiæ Vegetabiles" (Dr. W. Junk, The Hague), which it is hoped will become the official organ of the Confoederatio Internationalis ad Qualitates Plantarum Edulium Perquirendas.

J. Friend

RESEARCH DIVISION OF THE CEMENT AND CONCRETE ASSOCIATION, WEXHAM SPRINGS

THE Cement and Concrete Association is the research and information organization of the Portland cement industry in Britain. Its research and development station is at Wexham Springs, Stoke Poges, Buckinghamshire, where on May 1 the Minister of Works, the Right Hon. Hugh Molson, M.P., opened three new buildings.

These buildings comprise, first, a two-story block containing a printing department, canteen and self-contained hostel with lecture theatre and recreation rooms capable of housing about forty students; secondly, a demonstration hall with an unobstructed floor space, 50 ft. × 100 ft., in which building techniques can be demonstrated in full scale, under cover; and thirdly, chemistry and physics laboratories.

The research station is concerned essentially with the utilization of Portland cement, problems of manufacture being studied elsewhere, and it endeavours to promote the more efficient utilization of cement, as well as finding new applications and acting as a technical service unit for all users of cement. Its activities are carried on by a staff of about twenty graduates and some eighty experimental assistants, tradesmen and labourers in five departments, covering chemistry and physics; concrete (materials and methods of preparation); structural engineering; roads and airfields; works and general services.

The Chemistry and Physics Department concerns itself with chemical and physical problems arising in concrete construction, fundamental research on the nature of hardened cement and maintenance of a standards and instrumentation section which provides facilities for making measurements and the construction of special apparatus. The pure research of the Department is directed to the elucidation of the fundamental structure of hardened cement pastes. For this purpose physical methods of analysis are mainly employed, chiefly X-ray powder photography, measurement of dielectric properties and the study of phase equilibria in the system $CaO—SiO_2—H_2O$.

Applied research has embraced a range of problems some of which, such as the study of the durability of concrete exposed to weathering and chemical attack, are long-term and of indefinite duration. Others have been simple and have required only a few hours work. In this category come measurements

of the heat capacity and thermal insulation of concrete walls and floors, and routine analytical tests to determine cement contents of concrete and identify attacking agents. The instrument section provides facilities for the servicing of electrical apparatus and undertakes the design and construction for other departments of instruments which are not available from commercial sources.

The Concrete Department is devoted to the study of the materials for making concrete and to the examination of concrete-making techniques designed to provide specific properties in the final product.

The materials section has the general objective of improving the practice of preparation of aggregates and the design of concrete mixes. To this end it studies methods of testing aggregates and cement, and of assessing the qualities required of concrete as an engineering material. Systematic investigation has enabled the factors which cause variation in quality of concrete to be identified and measured, and has made it possible to design, from widely variable raw materials, mixes which will give concrete having desired properties.

The basic research of the materials section has provided the informed background for the work of the methods section, which examines special uses of concrete and concentrates on improvements in the technique employed. A detailed study has been made of the procedure for laying granolithic floor toppings and a fundamental investigation is being made of frost damage to concrete kerbstones. As part of this work the shrinkage and creep of concrete are being examined with novel apparatus, particular attention being paid to dimensional changes in the setting and hardening period.

The Structural Engineering Department is concerned with the improvement of design methods for concrete structures, improvement of the knowledge of the behaviour of concrete structures, development of new concrete structural forms, and the study of practical constructural problems. The design studies are carried on in close collaboration with other engineering research laboratories and with practising engineers. The Department is fortunate in having available a specially designed laboratory in which tests can be made on full-scale elements of structures or on models of a size which approaches full-scale. Testing is carried out with a large test frame, the base of which is the heavily reinforced floor of the laboratory, and loading is by means of hydraulic jacks. The performance of the structure under test is examined by mechanical and electrical strain gauges and can be recorded automatically.

A special study has been made of the design of shell roofs, of the effect of concentrated loads on bridge decks and of the properties of prestressed concrete structures. The Department has also been able to collaborate with engineers on actual construction, and much valuable information has been obtained relating the performance of laboratory models to that realized in the full-scale structure.

The Roads Department was formed to carry out research and development work on all forms of pavement construction in which cement is used. Its principal interest has been in concrete pavements, lean concrete bases and cement-stabilized soil bases. Experimental work has been carried out on techniques of road laying and of the details of road construction, such as joint making, repair and resurfacing. The Department maintains a close interest in road and airfield work in progress, and its services are extended to site control of unusual and/or particularly important projects. Advisory work is also undertaken for local authorities and others concerned with the building of new roads.

The basic function of the Works and Services Department is the provision of a service of craftsmen and labourers for carrying out all kinds of building operations. All departments call upon the services of this Department for routine maintenance of plant and property and for the carrying out of building experiments which involve the skill of tradesmen. The Department also carries out investigations in its own right and has been particularly interested in the development of attractive surface finishes for concrete. Some hundreds of examples of different surface finishes are undergoing weathering trials on the Station, and architects and others interested in applying them are provided with detailed instructions how to achieve the effects. A further substantial part of the various work of this Department is the organization of field work for training courses. Every year training courses for about forty persons are held at roughly fortnightly intervals, and one of the functions of the Works and Services Department is to arrange full-scale demonstrations of various aspects of concrete technology ranging from simple batching trials to complete demonstration of prestressing techniques.

These training courses are organized by another division of the Cement and Concrete Association, but it was felt most appropriate to hold the courses where the research work is in progress. The success of the courses and the importance attached to communication of the fruits of research are underlined by the decision to provide two of the new buildings mainly for training purposes.

RESEARCH COUNCIL OF ALBERTA

REPORT FOR 1956

THE thirty-seventh annual report of the Research Council of Alberta*, which includes the usual lists of publications of the Council, members of committees, and staff, covers the year 1956, in which the formal opening of the Council's new laboratories and pilot plant on a site adjacent to the University of Alberta was the outstanding feature. The Council's geological effort was further strengthened during the year, and two new advisory committees were established, one dealing with agricultural matters and the other with the problem of hail, commencing with a study of basic cloud physics in co-operation with the Meteorological Division of the Department of Transport.

Encouraging progress was made in coal research, the major effort of the organic chemistry laboratory being concerned with the constitution of humic acids and further studies of the pyrolysis of coal in presence of acid catalysts. Comparison of the infra-red spectra of humic acids, coals and synthetic coal-like substances prepared by oxidative polymerization of hydroquinone at high temperatures suggests that while the concept of a continuous increase of rank in coals is sound, materials giving infra-red spectra typical of bituminous coal may be found in various ways. The Physical Chemistry Laboratory has studied the mechanism of pyrolysis of coal and the

* Research Council of Alberta. Thirty-seventh Annual Report, 1956. Pp. 48. (Edmonton: Queen's Printer, 1957.)

solubility of partly carbonized coal. Palæobotanical studies have concentrated on fossil woods and spores, and the collection of modern conifer woods, begun in 1955, is now virtually complete. So also is the first stage of the fluidized coal carbonization programme begun in 1955 in co-operation with the University Department of Chemical Engineering, and it was anticipated that the equipment would be transferred to the Council's new pilot plant in the spring or early summer of 1957. Tests in Germany indicate that it is not possible to manufacture binderless briquettes of commercial quality from Alberta sub-bituminous coal in either extrusion-type or high-pressure ring-roll presses, but the possibility of using hot-briquetting processes is being explored in Europe.

Petroleum geochemistry is now recognized as the unifying theme in the work on petroleum, and the programme is being co-ordinated on this principle. Work continued on the porphyrin content of oil and its destruction in relation to the presence of vanadium, nickel and other trace elements. A detailed survey is being made of the occurrence of vanadium and nickel in the Pembina oil field with a view of following oil migration within the field, and the flow of Athabasca oil sand through a hopper is also being studied. Other work has been concerned with the characterization of the sulphur compounds in the oil-sands oil, and the selective oxidation of thiophenic acid sulphur by nitric acid. The hydrocarbon research programme deals with the mechanism of the uncatalysed pyrolysis of hydrocarbons and the decomposition of halo-hydrocarbons.

The work on natural gas has been reoriented, and yields of acetylene and ethylene in the range of commercial interest were obtained by pyrolysis of *n*-butane at about 250° F. and atmospheric pressure, greater severity of cracking favouring the formation of acetylene. Particular emphasis is being placed on the engineering problems associated with the high heat load required for such pyrolytic reactions, and fundamental studies are being made on adsorption with reference to the use of such techniques in separating hydrocarbons.

The geological section is making excellent progress with its ground-water programme, and the surficial geology of the Hardisty–Killam–Kinsella area was mapped on a scale of one inch to one mile. A Cretaceous microfaunal study was completed in co-operation with the University of Alberta and a microfaunal research project on the Exshaw formation initiated. The clay fraction of shale samples collected across the contact of the non-marine Oldham formation and the marine Bearpaw formation is being studied by X-ray diffraction, and chemical analysis and detailed petrographic and stratigraphic studies of the Lower Cretaceous Blairmore formation of southern and central Alberta continued.

Reconnaissance oil surveys were made on 500,000 acres in the Blueberry Mountain sheet, and some 10 million acres were covered in the exploratory soil survey by helicopter from the Lesser Slave Lake to the Saskatchewan boundary. Additional data were accumulated, despite unusually heavy rainfall, in the co-operative irrigation research on solanetzic soils. The highway research programme included fundamental studies on the use of electro-osmosis to inject chemicals into soils of the texture of silts and finer, as well as on the use of chrome–lignin gels for soil stabilization and for the prevention of frost heaving in soils. Comprehensive laboratory tests were made on samples of soils taken from test-holes in areas of extensive slides which have occurred in the vicinity of the town of Peace River.

The industrial engineering services section is primarily a service group, but it undertook some investigations, including work in co-operation with the University Department of Agricultural Engineering on the utilization of butane in engines. Work in animal science included a study of the influence of the productive energy level of the ration in the reproductive performance and efficiency of turkeys, and a study of the nutritive value of rapeseed oil meal.

HYDRO-ELECTRIC POWER IN THE U.S.S.R.

IT is always a matter of interest to the Western world when the veil of secrecy surrounding many of the activities of the inhabitants of the U.S.S.R. is lifted a little. A report was presented to a joint meeting on May 20 of the Institutions of Civil, Electrical and Mechanical Engineers on the visit of six British engineers to the U.S.S.R. to examine the hydro-electric installations there. It is clear that their hosts spared no effort to provide these visitors with the information they desired, especially with regard to those parts of their vast territory which they were unable to visit. It is also refreshingly clear that the visitors were determined to supplement this information with the results of their own observations of the installations and factories seen. In so far as the use of electricity is a pointer to the progress of industrialization of a community, the report is of value in showing the position achieved by the U.S.S.R., and some interesting comparisons with Great Britain are possible. There is a great wealth of factual information given, which makes the report heavy reading, although correspondingly more valuable, and a fair summary of the report must also, therefore, be mainly concerned with facts.

At the present time the electricity generated in the U.S.S.R. per head of population is rather less than half the corresponding figure for Great Britain. This may be accounted for to some extent by the greater proportion of rural to urban population; but another contributory factor is the more extended use of combined steam-power stations, where the heat of combustion of the fuel is partly used to generate electricity and partly used to provide steam for industrial purposes and for space-heating. This dual-purpose type of station is more attractive economically in the U.S.S.R. than in Great Britain on account of the higher proportion of the urban population who live in large blocks of flats, and 30 per cent of the plant capacity of thermal stations is in combined stations.

The rate of growth of electricity consumption in the next five years is estimated at 45 per cent (9 per cent per annum) for Great Britain, and at 88 per cent for the U.S.S.R. If these rates of progress are maintained, the U.S.S.R. should consume more electricity per head than Great Britain by 1967. Of this total electricity generated, the proportion produced by hydro-electric power is 13·5 per cent at present but is estimated to approach 20 per cent by 1960.

The potential hydro-electric power generation of the country is enormous, and has been estimated as

approximately eighteen times the total consumption of electricity in the U.S.S.R. to-day. Probably only 50 per cent of this can be developed economically, but even this figure provides a comfortable margin over the country's needs for many years to come. Research work is, however, being undertaken on peaceful uses of atomic energy, and atomic power stations are planned for areas where there are no local supplies of fuel and presumably no hydro-electric supplies of power.

The development of hydro-electric supplies is always combined with plans to improve the navigability of rivers and to improve irrigation. In most schemes rivers are converted into a series of large lakes and this must entail some loss of potential power through increased evaporation. In one scheme, however, in Armenia, it is proposed to lower the level of Lake Sevan over a period of fifty years in order to reduce the loss due to evaporation. According to the original scheme, the lake was to be reduced to one-sixth of its area, but a less drastic reduction is now under consideration, coupled with the diversion of water from other watersheds to make good the power lost.

The visiting engineers were generally favourably impressed with the quality of the constructional work carried out and with the technical knowledge of the engineers in control, but they mention seeing several instances of the use of rather poor concrete, and the finish of both constructional work and machinery was not always up to the best British practice. One interesting feature was the small use made of timber shuttering, pre-fabricated permanent concrete shuttering being more generally used.

Many of the structures and earthworks are founded on permeable material and a considerable research effort is devoted to the study of soil mechanics and the strength of materials and structures. Extensive use is made of models before starting full-scale construction. Most of the hydro-electric machinery is manufactured in the U.S.S.R., but the party were only able to visit two manufacturing plants. Factory workers work forty-six hours a week including six on Saturday. Overtime is paid at time and a half for the first two hours of each day and then at double time. There are also bonus incentives.

Eighty per cent of the potential water power of the country is east of the Urals, in relatively thinly populated areas, and considerable attention has, therefore, been given to transmission problems. A 400 kV. a.c. overhead line between Kuibishev and Moscow, a distance of 500 miles, has recently been completed, and there is a proposal for an 800 kV. d.c. line between Stalingrad and the Donbas area, a distance of 250 miles. Some indication of policy in the matter of electricity consumption is afforded by the fact that the private consumer may have to pay thirty times as much for his electricity as a favoured industrial consumer.

There is an interesting appendix giving the estimated total production in 1960 showing increases above 1955 ranging from 23 per cent up to a twenty-one-fold increase. Comparable British figures would have been helpful here, especially for the general consumption goods. These figures show, for example, two pairs of footwear per head of population and approximately one refrigerator, one washing machine and one motor tricycle for every 400 members of the population, as the annual production in 1960.

The members of the visiting party were Sir John Hacking, of Merz and McLellan; Mr. A. A. Fulton, of the North of Scotland Hydro-Electric Board; Dr. S. P. Hutton, of the Department of Scientific and Industrial Research Mechanical Engineering Research Laboratory; Dr. W. MacGregor, of George Wimpey and Co., Ltd.; Mr. R. W. Mountain, of Kennedy and Donkin; and Mr. H. West, of Metropolitan-Vickers Electrical Co., Ltd. A. H. M. Arnold

FRANKLIN INSTITUTE

REPORT FOR 1956

At the annual meeting of the Franklin Institute which was held on January 16, the president, Mr. S. Wyman Rolph, gave a brief summary of the activities of the Institute during 1956. The full text of the annual report of the board of managers appears in the March number of the *Journal of the Franklin Institute* (263, 229; 1957).

The report states that the year under review was a successful one, both financially and otherwise, for the Institute. The Laboratories for Research and Development, which celebrated their tenth anniversary in March 1956, became not only self-supporting but even accumulated a surplus, which can be used for the purchase of much-needed additional equipment. For the first time the gross value of the wide range of investigations carried out for industrial sponsors and the United States government exceeded 3 million dollars. The greatest increase in effort occurred in the field of nuclear engineering, and in November a separate Nuclear Engineering Division was established to handle this particular work. The work on air pollution, carried out by the Division of Chemistry and Physics, was expanded considerably, and a mobile laboratory for the analysis of polluted air was used to study the 'smog' problem in the Los Angeles area. A public semi-technical symposium on the subject of air pollution was held at the Institute in October during Philadelphia's 'Cleaner Air Week'. An electronic recorder for the recording of transient events in proper time sequence, which is most useful in the study of mechanical strains and in chemical kinetics, was designed and constructed by the electronics section of the Electrical Engineering Division, and a Remington-Rand 'Univac' digital computer has been installed, which will be used by the analysis section of the Division to solve engineering problems arising from projects in various departments of the Laboratories and also will be available for data processing for other organizations.

The circulation of the Institute's *Journal* increased from 4,734 at the end of 1955 to 4,876 at the end of 1956. The January 1956 issue commemorated the 250th anniversary of the birth of Benjamin Franklin. The group of associate editors of the *Journal* was increased during the year by eight new appointments to widen the coverage in electronics, mathematics, aerodynamics, thermodynamics, solid state physics, biophysics and nuclear engineering. Commencing with the July issue, Dr. J. S. Burlew succeeded Dr. H. B. Allen as editor. This followed Dr. Allen's retirement in January from the positions of executive vice-president and secretary of the Institute, and the appointment of Dr. Burlew as executive vice-president and Mr. H. V. Bail as secretary. In order to make the facilities of the Laboratories better known to industry, the Institute

has commenced publication of a series of brochures, of which two, dealing with computation services and industrial colloids and polymers respectively, appeared during 1956. A symposium on "Earth Satellites as Research Vehicles" was held on April 18 as part of a programme to promote the peaceful use of rockets; the full proceedings have since been published as Monograph No. 2.

Details are given in the report of the various meetings and scientific lectures held by the Institute during the year under review; the awards of the Franklin and other medals by the Committee on Science and the Arts; the activities of the Bartol Research Foundation and the Biochemical Research Foundation; the changes in the number of the staff, which increased by twenty to 556; and preliminary figures concerning the finances of the Institute. Separate sections of the report deal with the Museum and public relations. The Museum attendance showed a further increase, continuing the upward trend which commenced in 1951. About 40 per cent of the total of 336,000 visitors were in groups of school children, and for some of them the Museum's Education Division arranged special programmes designed to interest the young people in careers in science and engineering as part of the Institute's effort to help alleviate the shortage of trained people in those professions.

Several events in connexion with the celebration of the Benjamin Franklin anniversary took place at the Institute. A luncheon was held on Franklin's birthday (January 17), at which the City of Philadelphia's special Franklin Medal was presented to Mrs. Eleanor Roosevelt. The Institute has also been responsible for several series of radio and television programmes, including a weekly feature "Science, Servant of Man", which was broadcast from four separate stations. The anniversary celebrations and the broadcasts were all handled through the public relations department of the Institute.

THE WILDFOWL TRUST

READERS of the eighth report of the Wildfowl Trust, Slimbridge, Glos, will quickly detect the quiet pride and confidence which the editors, Peter Scott and Hugh Boyd, and the contributors have managed to convey. The visit of H.M. the Queen in 1956 set a seal on the Trust's first ten years of life and gave it a recognition so well deserved.

The Trust has three main lines of activity and the way in which each of these has expanded is clearly brought out in a report which covers a period of two years. As the results of its earlier work have become known, the Trust's research programme has received increasing outside recognition. Although much of the scientific work is paid for by the Trust itself, the Nature Conservancy has been able to offer increased assistance, while considerable help has been obtained from other, non-governmental, bodies.

In the educational field the value of the Trust's collection has been recognized by a spectacular increase in the number of schools and organized parties visiting Slimbridge. This number rose from 374 in 1953 to 464 in 1954 and 719 in 1955. The recreational value of Slimbridge was reflected in the growth of the number of visitors from 40,000 in 1954 to 90,000 in 1955 and more than 120,000 in 1956.

Although the numbers of wild geese seen at Slimbridge showed no striking increases during 1954–56, the ringing of geese and ducks, there and at other stations, expanded considerably. In 1954 the Trust assumed a large measure of administrative and financial responsibility for duck ringing in Britain. All the eight ringing stations are in the southern half of England and Wales and there is urgent need for ringing to be undertaken farther north and in Scotland and Ireland; this will be done as more money becomes available.

Although the population study of the pink-footed goose continues to be the main Trust investigation, studies were also made of comparatively small-scale ringing of greylags and white-fronted geese. These studies are particularly valuable for the indication they give of the general resemblances between the population dynamics of all three species despite the differences in their breeding places and migration routes and the extent to which they are pursued by man in Britain and other countries. An important parallel to the pinkfoot inquiry is provided by a study of the blue and lesser snow geese of North America by Graham Cooch, of the Canadian Wildlife Service. In his article, Cooch describes his technique for catching these geese during the flightless period of the moult; the method has been based on long-established Eskimo techniques.

Two complementary articles are concerned with wildfowl conservation in North America and in Europe. The first, by F. C. Bellrose and T. G. Scott, deals with conservation in North America since 1945. The second, by Hugh Boyd, shows how American experience has been used on the problems of re-stocking with hand-reared ducks in Britain; evidence collected by Boyd suggests that it is unlikely that hand-reared ducks can improve shooting on the foreshore.

Besides a wonderful collection of photographs and some black-and-white drawings which could have come only from the pen of the Director, the report contains all the financial information to show that the Trust is now well established; it must be congratulated on selling Christmas cards to the value of £1,341 in one year.

VARIATION IN THE NUMBER OF BUTTERCUP PETALS

FOR five successive years, girls of Westonbirt School have kept a record of the variation shown in the numbers of petals in buttercups. The species investigated was chiefly *Ranunculus acris* with some *R. bulbosus*, and no attempt was made to distinguish between the two in petal variation. The work was done by girls in the second year of a general science course, their average age being 12–13 years. It was carried out when they were first introduced to flower structure and function and could profitably be done by younger or older children. An account of the study has been given by E. A. Potter (*School Nature Study*, 52, No. 207; April 1957).

In the first lesson, each girl had a number of flowers, which she examined, noting and describing in the usual way the number and shape of the various parts. The number of sepals was found to be constant at five, and this result was anticipated for petals. Although the majority of flowers had five petals, there was considerable surprise when some with six,

seven and even eight were discovered. Further investigation showed that 'sixes' were very common and that there were 'sevens', 'eights', 'nines', and 'tens' in decreasing numbers. Later many more variants were found, the numbers of petals varying from four to twenty-five. These were tabulated statistically and supported by investigations during the following year. These showed that 'fours' are rare, and that flowers with thirty or more petals were occasionally found. Plants with these 'double' flowers were few in number, and all were growing in a small area within a few inches of each other. Some plants bore only one 'double' and many single flowers; others bore a few flowers, all 'double', though not necessarily with the same number of petals in each, and no single flowers. In counting the petals of 'double' flowers it was often difficult to distinguish them from stamens, the inner petals being abnormal in shape, much narrower, sometimes tubular at the base and almost staminoid. In all flowers with petals other than five, there was no variation from the normal five sepals.

There is much of value in a simple investigation of this kind. It stimulates the class to take an added interest in the buttercup, it introduces pupils at an early stage of their biology course to the use of statistical method, obviously of a simple type but yet quantitative, where so much of this branch of science is of necessity qualitative. It also encourages pupils not to accept statements such as "the buttercup has five petals", but to question and discover the truth for themselves.

MIDDAY CLOSURE OF STOMATA

Temperature Effects on the Minimum Intercellular Space Carbon Dioxide Concentration "Γ"

Loftfield[1] observed that the stomata of alfalfa, onion and many other plants sometimes closed partially or completely at about midday, reopening later in the afternoon, and Sayre[2] made similar observations for *Rumex patientia*; such closure was not generally accompanied by any obvious correlative changes in the starch contents of the stomatal guard cells in alfalfa or *R. patientia* (onion stomata do not contain starch). Both Sayre and Loftfield attributed midday closure to water-strain, but the large and rapid increases of stomatal starch that normally accompany wilting (for example, Iljin[3]) render this explanation implausible. Nutman[4] obtained evidence that the midday closure of *Coffea arabica* stomata was not due to water-strain and he concluded that high light intensity was the cause; the closure was accompanied by a fall in apparent assimilation rate, but in view of the control of stomatal aperture by the carbon dioxide concentration in the intercellular space system[5–8] a doubt exists as to which was cause and which effect. Heath[8] found that high temperature, above about 25° C., exerted a closing effect upon the stomata of the onion and interpreted this in terms of intercellular space and guard cell carbon dioxide contents. Like Parkin[10], he was under the misapprehension that onion stomata were free of chloroplasts[11–13], but he also directed attention to the unusually high ratio of non-chlorophyllous to green tissue in the onion leaf which might be expected to cause an especially pronounced increase in intercellular space carbon dioxide content with rising temperature. He suggested that the midday closure of onion stomata, and by implication that of *Coffea* stomata also, was a high-temperature effect operating *via* internal carbon dioxide content.

It was found by Miller and Burr[14] for whole plants and by Gabrielsen[15] and Heath[16–18] using detached leaves that photosynthesis by leaves illuminated with 1,000–2,500 f.c. could only reduce the carbon dioxide content of the air to about 100 p.p.m.; Heath[17,18] interpreted this as the minimum concentration at the surface of the assimilating mesophyll cells. Miller and Burr[14] claimed that this concentration, which will here be denoted by the symbol Γ, was independent of temperature, but Egle and Schenk[19] and the present authors (unpublished) later showed that Γ increased markedly with temperature. The more general aspects of this work will be published later, but a special investigation of temperature effects on Γ for onion, *C. arabica* and *Pelargonium zonale* leaves was made with reference to the problem of midday closure. Heath and co-workers[7,8] had found that wheat stomata (at 25° C.) showed a closing response to increasing carbon dioxide concentration, but only from 100 p.p.m. upwards; a survey experiment on

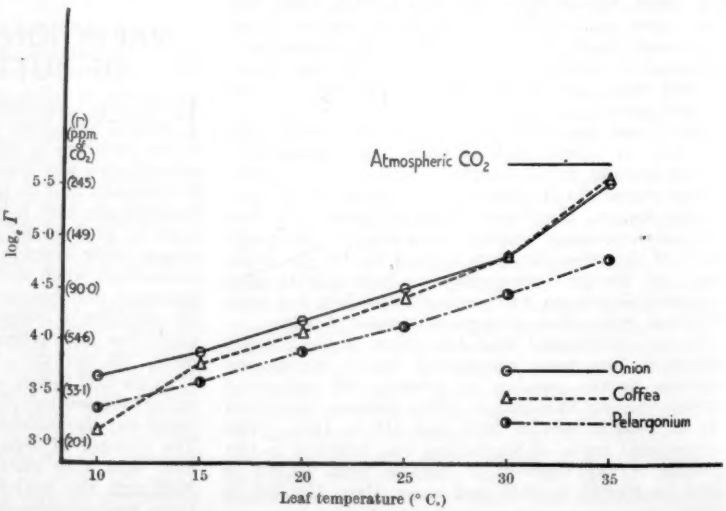

Fig. 1

the effects of light intensity and temperature on Γ for a number of species suggested that high temperatures within the physiological range might raise Γ appreciably above 100 p.p.m., thus causing stomatal closure.

The determinations of Γ in air which circulated over the detached leaves in a closed system were made with a Grubb Parsons infra-red gas analyser. The leaf chamber and lead-in tube were immersed in a thermostat bath which was adjusted to maintain the leaf at the desired temperature as indicated by a galvanometer connected to a small thermocouple in contact with the lower leaf surface (or for onion within the leaf cavity). The light intensity was maintained constant at 900 f.c. (tungsten filament) and Γ was determined at 5 deg. C. intervals of leaf temperature from 10° C. to 35° C. inclusive.

The data are shown in Fig. 1 as $\log_e \Gamma$. Owing to shortage of satisfactory *C. arabica* leaves the curve for that species is for one leaf only; the other data represent mean values for three leaves. For *Pelargonium*, which has not been reported as showing midday closure, $\log_e \Gamma$ increased almost linearly with temperature over the whole range, Γ having a relative increase of about 30 per cent for each 5 deg. C. interval and reaching 120 p.p.m. at a leaf temperature of 35° C. For onion and *Coffea*, on the other hand, $\log_e \Gamma$ increased in a similar manner to 30° C., but then rose very steeply, Γ increasing from about 120 p.p.m. at 30° C. to about 250 p.p.m. at 35° C.; the relative increase for onion over this last interval was very significantly ($P < 0{\cdot}001$) greater than the others for either onion or *Pelargonium*, as shown by analysis of variance on log Γ and *t* tests. It should be noted that cut lengths of onion leaf were used in which the leaf cavity, lined with non-green tissue, was open to the circulating air and therefore presumably supplying respiratory carbon dioxide directly to it. Owing to the resistances to diffusion between this air and the substomatal cavities the concentrations in the latter would thus tend to be over-estimated by the measured values of Γ. Subsequent work (Heath and Meidner—unpublished) has shown this effect to be small and has confirmed that the log Γ curve rises very sharply between 30° C. and 35° C., both at 900 f.c. and at 300 f.c., even with the leaf cavity closed at the tip.

An indirect estimate of stomatal diffusive conductance was obtained from the difference between the controlled leaf temperature and the ambient temperature (as a measure of the cooling effect of transpiration) plotted against saturation-deficit; this indicated that the onion stomata closed slightly from 25° C. to 30° C. and markedly between 30° C. and 35° C., whereas those of *Pelargonium* showed no closure and even opened somewhat with rising temperature.

We consider that the closing effect of high temperature on onion stomata, coupled with the rapid increase of Γ between 30° C. and 35° C. shown by onion and *Coffea*, both species known to exhibit midday closure, strongly support the hypothesis that the latter phenomenon is a temperature effect operating through the intercellular space carbon dioxide content. This interpretation is also supported by Heath's[9] observation that the closing effect on onion stomata of a rise of temperature was over-ruled by the opening effect of a concurrent increase of light intensity, for the latter would tend to lower Γ. The light intensity used in the present experiments (900 f.c.) was admittedly considerably lower than midday daylight, but on the other hand, leaf temperatures above 35° C. could well occur under natural conditions—they were not used in this work for fear of after-effects upon the responses to the lower temperatures.

Further support for the hypothesis is given by data obtained by Heath and Meidner[20].

This investigation was carried out while one of us (B. O.) was receiving a maintenance grant from the Agricultural Research Council and forms part of work for which the Ph.D. degree of the University of London was awarded[21].

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Effects of Carbon Dioxide and Temperature on Stomata of *Allium cepa* L.

HEATH AND ORCHARD[1] put forward the hypothesis that midday closure of onion stomata might be explained in terms of the observed sudden increase in Γ (the estimated minimum intercellular space carbon dioxide concentration) between 30° C. and 35° C. This hypothesis has been tested in the following experiments:

Experiment 1. This was a 2 × 2 × 2 factorial experiment involving: (*a*) leaf temperatures of 25° C. and 35° C.; (*b*) light intensities of 300 f.c. and 900 f.c. (tungsten filament); (*c*) leaf cavities closed at the tip, as in the natural state, or open and swept with carbon dioxide-free air. The eight treatments were replicated three times (cut lengths of twenty-four leaves) and each was preceded by a standard treatment during which the stomata attained a steady-state opening value. Carbon dioxide-free air was blown against that portion of leaf surface which was used for 'transpiration porometer' measurements. (Details of the transpiration porometer will be published elsewhere.) Steady-state values were maintained for at least 25 min.; the percentage changes from those for the standard treatment were used as data.

At 25° C., at either light intensity, sweeping the leaf cavity with carbon dioxide-free air caused no significant changes in stomatal opening, as compared with unswept leaves with their cavity closed. Apparently at this temperature the accumulation of carbon dioxide in the hollow leaf was insufficient to affect the stomata appreciably, at least under these conditions when carbon dioxide-free air was blown

against the leaf externally. (At 25° C. and 900 f.c., $\Gamma = 90$ [1,2] or 70 p.p.m.[2]; at 25° C. and 300 f.c., $\Gamma = 108$ p.p.m.[2].) When the temperature was raised from 25° C. to 35° C., however, at each light intensity the stomata of leaves with the cavity closed underwent a significant closing movement ($P < 0{\cdot}001$ at 900 f.c. and $P < 0{\cdot}01$ at 300 f.c.; at 35° C. and 900 f.c. $\Gamma = 247$ p.p.m.[1,2], at 35° C. and 300 f.c. it would be higher still). This stomatal closure was not observed in leaves with the cavity swept by carbon dioxide-free air, thus supporting the hypothesis of Heath and Orchard, and in fact in such leaves illuminated at 900 f.c. a nearly significant stomatal opening occurred when the temperature was raised from 25° C. to 35° C. (see Experiment 2). This was in accord with the generally held opinion that high temperatures favour stomatal opening[3,4] and suggested that in onion leaves this might be true provided that the internal carbon dioxide concentration could be prevented from reaching too high a value. A further experiment was designed to test more accurately this second temperature effect as well as to provide evidence on the sensitivity of onion stomata to carbon dioxide concentration, which had not yet been directly demonstrated.

Experiment 2. Cut lengths of onion leaves were used in the transpiration porometer and the leaf cavities were swept continuously with moist air; steady-state values of stomatal conductance were maintained for at least 20 min. Four treatments were applied to each leaf, namely: carbon dioxide-free or ordinary air used for sweeping the leaf cavities and blowing on the leaf externally, combined with temperatures of 25° C. and 32° C. The experiment was repeated on four leaves with a light intensity of 300 f.c. throughout.

Carbon dioxide-free air caused wider opening than ordinary air at 25° C. and this difference was even greater at 32° C.; with carbon dioxide-free air the stomata opened farther at 32° C. than at 25° C. These effects were all highly significant ($P < 0{\cdot}001$). There was, however, no evidence of a difference in aperture at the two temperatures when ordinary air was used, suggesting that here the opening effect of the higher temperature was balanced by a closing effect due to its causing an increased carbon dioxide concentration in the guard cells; respiratory carbon dioxide from the chloroplast-free epidermal cells would contribute to this.

It has thus been established: (*a*) that onion stomata respond to increased carbon dioxide concentration by closure, as do those of other species; (*b*) that the high-temperature closure of onion stomata with the leaf cavity closed (as in Nature) can be accounted for by accumulation of carbon dioxide in the leaf; (*c*) that if accumulation of intercellular space carbon dioxide is prevented, high temperature causes opening. This opening effect of high temperature may perhaps not operate through carbon dioxide at all; on the other hand, it may be brought about by the lower solubility of carbon dioxide in the guard cell sap at high temperature.

Information about the effect of temperature on the rate of stomatal opening from darkness has been obtained from a separate experiment at 300 f.c., using carbon dioxide-free air. The rate of opening was significantly greater at 36° C. than at 26° C. ($P < 0{\cdot}001$), the Q_{10} being 2·35 with fiducial limits 2·24–2·46 for P 0·05. This confirms the approximate value of 2 found by Loftfield[5] for alfalfa out of doors and suggests that the rate of a chemical 'dark' reaction is primarily controlling the light opening at 300 f.c. even at such a high temperature range.

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TRIPHOSPHOPYRIDINE NUCLEOTIDE AS A CATALYST OF PHOTOSYNTHETIC PHOSPHORYLATION

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Photosynthetic phosphorylation[1–10] is a term used to describe the conversion of light energy into the energy-rich pyrophosphate bonds of adenosine triphosphate by isolated chloroplasts, without the aid of other cellular constituents. Isolated chloroplasts are capable of carrying out complete photosynthesis[1,6,11], but when conditions are so arranged that carbon dioxide fixation does not occur, photosynthetic phosphorylation proceeds outside the cell in accord with the overall reaction:

$$\text{Light} + P_i + \text{ADP} \rightarrow \text{ATP} \qquad (1)$$

where P_i represents orthophosphate and ADP and ATP represent adenosine diphosphate and triphosphate respectively.

The catalysts of photosynthetic phosphorylation which were previously identified are magnesium ions, riboflavin phosphate, vitamin K and ascorbate[3–9]. By varying experimental conditions, we have now found two additional catalysts for photosynthetic phosphorylation: triphosphopyridine nucleotide, and a factor present in an aqueous extract of chloroplasts, which appears to function in phosphorylation by reducing triphosphopyridine nucleotide in light. We have also found a method for stabilizing the activity of isolated chloroplasts, thereby enlarging the range of possible investigations of chloroplast reactions *in vitro*.

The effect of triphosphopyridine nucleotide on photosynthetic phosphorylation became apparent at

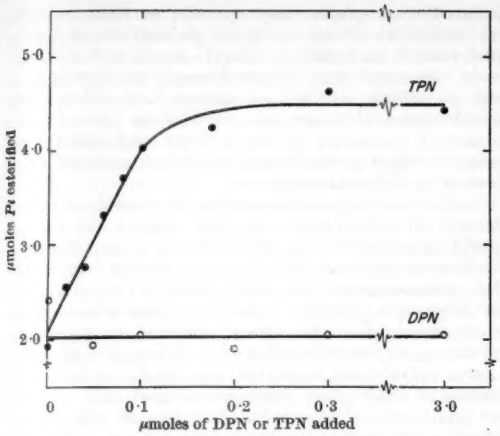

Fig 1. Effect of tri- and di-phosphopyridine nucleotide on photosynthetic phosphorylation.
The reaction mixture contained in a final volume of 3 ml.: 'broken' chloroplasts (ref. 9) containing 0·1 mgm. chlorophyll; *tris*-(hydroxymethyl) amino-methane buffer, *p*H 8·3, 80 μmoles; magnesium chloride, 5 μmoles; sodium ascorbate, 5 μmoles; riboflavin phosphate, 0·01 μmole; vitamin K_3, 0·06 μmole; adenosine diphosphate, 10 μmoles; $K_2H^{32}PO_4$, 10 μmoles; and tri- or di-phosphopyridine nucleotide as indicated. The reaction was run for 20 min. at 20° C. under nitrogen gas. The 'broken' chloroplasts ($P_{1,9}$) correspond to the $P_{1,w}$ preparation (ref. 9) except that they were broken by suspending whole chloroplasts in 0·035 *M* sodium chloride instead of water. Measurement of esterified phosphate and all other experimental conditions were as previously described (ref. 8). Illumination as described elsewhere (ref. 11)

a low concentration of riboflavin phosphate and vitamin K, when the concentration of chloroplast material in the reaction mixture was reduced to 0·1 mgm. chlorophyll in 3 ml., the *p*H changed to 8·3 and adenosine diphosphate used as the phosphate acceptor. Under these conditions, the requirement for triphosphopyridine nucleotide was found to be specific and not replaceable by diphosphopyridine nucleotide (Fig. 1). In the earlier experiments[8,9], five times as much chloroplast material was used, the *p*H was 7·4 and adenylic acid served as the phosphate acceptor.

Further modification of experimental procedure yielded evidence for a water-soluble component of the chloroplasts essential to photosynthetic phosphorylation. When chloroplast preparations, such as used in experiments represented by Fig. 1, were washed three times in dilute sodium chloride (0·035 *M*), they lost their capacity for photosynthetic phosphorylation (Table 1). This capacity was restored (Table 1) to the washed green particles upon the addition of an aqueous extract of whole chloroplasts[6,9].

Table 1. Effect of Chloroplast Extract and of Triphosphopyridine Nucleotide on Photosynthetic Phosphorylation

	Orthophosphate esterified (μmoles)
Complete system, dark	0·4
Complete system, illuminated	6·7
Chloroplast extract omitted	0·7
Triphosphopyridine nucleotide omitted	3·3
Chloroplasts omitted	0·1

Experimental conditions and reaction mixture were the same as described in legend to Fig. 1, except that broken chloroplasts were washed by suspension in 0·035 *M* sodium chloride followed by centrifugation at 20,000 *g* for 5 min. at 0° C. This washing and centrifuging procedure was repeated three times. The complete system also contained 0·3 μmole triphosphopyridine nucleotide and chloroplast extract obtained from a quantity of whole chloroplasts containing 0·5 mgm. chlorophyll

The chloroplast extract has previously been shown to be important in carbon dioxide fixation[6,7,9]. Its role in photosynthetic phosphorylation is at present under investigation, but its effect can be tentatively attributed, at least in part, to a factor required for the reduction of triphosphopyridine nucleotide by illuminated chloroplasts. Its ability to reduce triphosphopyridine nucleotide was established in separate experiments in which the reduction of substrate amounts of triphosphopyridine nucleotide was measured as a function of added chloroplast extract. Phosphorylation was excluded by omitting inorganic phosphate and the requisite co-factors. Reduced triphosphopyridine nucleotide accumulated, in agreement with the recent findings of San Pietro and Lang[12]. Fig. 2 shows that under these conditions the reduction of triphosphopyridine nucleotide was proportional to the amount of the chloroplast extract added. The reduction of triphosphopyridine nucleotide was also reduced, but in our case at a lower rate (compare ref. 12).

The triphosphopyridine nucleotide-reducing factor has some of the properties of a protein: it is non-dialysable, and it is sensitive to heating; heating for 3 min. at 100° C. inactivates it completely. It is stable to acetone and alcohol precipitation. It appears to contain sulphydryl groups, since the reduction of triphosphopyridine nucleotide in our system was severely inhibited by 5×10^{-4} *M* *p*-chloromercuribenzoate. If the triphosphopyridine nucleotide-reducing factor is a protein, then its effect on photosynthetic phosphorylation must be catalytic, since chloroplast preparations which esterified 4·5

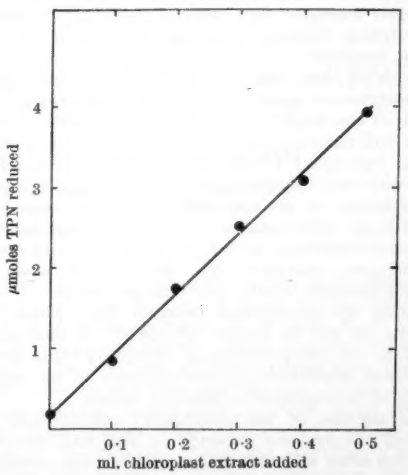

Fig. 2. Light-dependent reduction of triphosphopyridine nucleotide by washed chloroplast particles as a function of added chloroplast extract.
The reaction mixture contained, in a final volume of 3 ml.: 'broken' chloroplasts ($P_{1,9}$), containing 0·1 mgm. chlorophyll; *tris*-(hydroxymethyl) amino-methane buffer, *p*H 8·3, 80 μmoles; sodium chloride, 35 μmoles; triphosphopyridine nucleotide, 6 μmoles; and chloroplast extract as indicated. Chloroplast extract was prepared as described previously (ref. 9), except that 0·035 *M* sodium chloride instead of water was used as the extractant. 1 ml. chloroplast extract was obtained from a quantity of chloroplasts containing 2 mgm. chlorophyll. The reaction was run to completion at 20° C. under nitrogen, with potassium hydroxide in the centre well of the manometer vessel. Illumination as described elsewhere (ref. 11). After centrifuging off the particles, reduced triphosphopyridine nucleotide in the supernatant fluid was measured spectrophotometrically at 340μ

Table 2. Equivalence of Triphosphopyridine Reduction and Oxygen Evolution by Illuminated Chloroplast Particles in the Presence of Excess Chloroplast Extract

Triphosphopyridine nucleotide added (μmoles)	Triphosphopyridine nucleotide reduced (μmoles)	Oxygen evolved (μmoles)
0	0·1	0·2
1·0	0·9	1·2
2·0	1·9	2·2
3·0	2·9	3·1
4·0	4·1	4·2

Experimental conditions were as described in legend to Fig. 2, except that chloroplast extract obtained from chloroplasts containing 2 mgm. chlorophyll was added in each case. Triphosphopyridine nucleotide added as indicated. Oxygen evolution was measured manometrically and reduced triphosphopyridine nucleotide was determined as described in legend to Fig. 2

micromoles of inorganic phosphate (Fig. 1) contained only a very small amount of protein (about 0·1 mgm. of total nitrogen in association with 0·1 mgm. of chlorophyll).

As shown in Fig. 2, in a non-phosphorylating system, the reduction of substrate amounts of triphosphopyridine nucleotide (4 μmoles) by catalytic amounts of chlorophyll (0·1 μmole) was made possible by the addition of large amounts of the triphosphopyridine nucleotide-reducing factor. When this factor was present in excess, the reaction went to completion and the accumulation of reduced triphosphopyridine nucleotide was accompanied by a stoichiometric evolution of oxygen (Table 2) in accordance with equation 2:

$$TPN^+ + H_2O \xrightarrow[\text{chloroplasts + extract}]{h\nu} TPNH + H^+ + \tfrac{1}{2}O_2 \quad (2)$$

Hitherto, light-dependent evolution of oxygen in the presence of triphosphopyridine nucleotide as the hydrogen acceptor has been shown only indirectly by coupling reaction (2) with a suitable dehydrogenase system[13]. Direct evolution of oxygen by reaction (2) was also considered to be difficult on thermodynamic grounds[5,14]. For these reasons the nature of the triphosphopyridine nucleotide-reducing factor and the possible role of its SH-groups are of special interest. It can reduce triphosphopyridine nucleotide only in the light and only with the aid of chloroplasts; it cannot reduce it in the dark, with or without chloroplasts. The triphosphopyridine nucleotide-reducing factor seems to be unnecessary for oxygen evolution by chloroplasts when the reaction does not involve pyridine nucleotides. Oxygen evolution by illuminated, washed chloroplasts with quinone as the hydrogen acceptor[15] (a reaction we found to be independent of added pyridine nucleotides) was unaffected by the omission of the triphosphopyridine nucleotide-reducing factor.

The success of photosynthetic experiments with isolated chloroplasts depends on the stability of the particles after they are removed from the intact cell. With certain chloroplast preparations, a serious loss of activity occurred in unwashed chloroplasts on standing even at low temperatures. In experiments in which chloroplasts were washed, it was important to distinguish between loss of phosphorylating activity resulting from washing and that resulting from the mere delay which the washing procedure entailed. We have now found that the loss of activity on standing can be prevented for a period of several hours if the solutions used for grinding the leaves and washing the isolated chloroplasts contain 0·01 *M* ascorbate. The protective role of ascorbate on isolated chloroplasts may explain, at least in part, its beneficial effect on their photosynthetic phosphorylation and carbon dioxide fixation[1,8,9]. Moreover, seasonal and environmental fluctuations in the ascorbate content of leaves and chloroplasts could conceivably account, at least in part, for the observed variations in the activity and stability of spinach chloroplasts prepared at various times from leaves of different origin.

Since the triphosphopyridine nucleotide-reducing factor of chloroplasts can also reduce diphosphopyridine nucleotide, careful attention to experimental conditions was necessary to demonstrate its specificity for photosynthetic phosphorylation. The specificity of triphosphopyridine nucleotide was observed at concentrations of chloroplast material corresponding to 0·1 mgm. chlorophyll/3 ml. When five times as much chloroplast material was used, or when an excess of chloroplast extract was used, the addition of diphosphopyridine nucleotide was as effective as that of triphosphopyridine nucleotide in increasing photosynthetic phosphorylation. It is conceivable that the non-specificity at the higher concentration of chloroplast material resulted from the presence of bound triphosphopyridine nucleotide and sufficient pyridine nucleotide transhydrogenase[16] to catalyse the reaction:

$$DPNH + TPN \rightleftarrows TPNH + DPN \quad (3)$$

The specificity of triphosphopyridine nucleotide for photosynthetic phosphorylation is of special interest if our hypothesis[5–7] is correct that this process, like the more familiar respiratory phosphorylation by mitochondria, represents phosphorylation coupled to an electron transfer chain. In respiratory phosphorylation, so far as is now known[17–19] diphosphopyridine nucleotide, but not triphosphopyridine nucleotide, can serve as the initial electron acceptor. The findings reported here provide the first experimental evidence for the direct participation of triphosphopyridine nucleotide in what is envisaged as a coupled phosphorylation.

The new evidence allows us to include triphosphopyridine nucleotide as a hydrogen or electron carrier not only in carbon dioxide fixation, as was reported earlier[8–9], but also in photosynthetic phosphorylation by isolated chloroplasts. This conclusion is in accord with the identification of a reduced triphosphopyridine nucleotide diaphorase in leaf extracts by Whatley[20] and the recent isolation of this enzyme from chloroplasts by Avron and Jagendorf[21]. They have found[21] this enzyme capable of oxidizing reduced triphosphopyridine nucleotide and of transferring electrons from reduced triphosphopyridine nucleotide to riboflavin phosphate and menadione, two known catalysts[3–7] of photosynthetic phosphorylation.

If triphosphopyridine nucleotide has the same role of initial electron acceptor in photosynthetic phosphorylation as that which diphosphopyridine nucleotide has in respiratory phosphorylation, then the two processes appear to differ in both their initial and terminal electron acceptors. The terminal electron acceptor in respiratory phosphorylation by mitochondria is molecular oxygen. The terminal electron acceptor in photosynthetic phosphorylation by chloroplasts is not molecular oxygen but some as yet unidentified oxidized product of the light reaction. Chloroplasts will not carry on phosphorylation in the dark with reduced triphosphopyridine nucleotide and molecular oxygen. These differences support the view expressed earlier[5–9,10] that photosynthetic and respira-

tory generation of adenosine triphosphate, occurring at two different sites in the green cell, are catalysed by two different enzyme systems. This conclusion does not rule out the possibility that certain individual enzymes and reactions in photosynthetic phosphorylation are similar to those in respiratory phosphorylation.

The high rates of photosynthetic phosphorylation which were attained in some recent experiments may be of interest. The most active chloroplast preparations esterified 400 μmoles of phosphate per hr. per mgm. chlorophyll (or per mgm. nitrogen). These rates are more than a hundred times greater than those first reported[1] and are comparable with maximum rates of conversion of light into chemical energy during photosynthesis by whole leaves in saturating light and carbon dioxide supply[22], namely, 200 μmoles oxygen per hr. per mgm. chlorophyll.

After this work was completed, there appeared the report by Avron and Jagendorf[23] of an extractable chloroplast factor essential for photosynthetic phosphorylation. Their factor was prepared by a procedure similar to that which we have used in extracting the triphosphopyridine nucleotide-reducing factor, but the authors seem to have tentatively ruled out the reduction of pyridine nucleotides as a function of the extract. Another difference between our results and those of Avron and Jagendorf is the inability of their washed chloroplasts to use adenosine diphosphate as a phosphate acceptor. Our washed chloroplasts used adenosine diphosphate in preference to adenosine monophosphate, resembling in this respect the particles from photosynthetic bacteria investigated by Frenkel[24].

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SEROLOGICAL CHANGES CONCOMITANT WITH THE GROWTH OF MOUSE TUMOURS IN PRETREATED RATS

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A TRANSPLANTABLE mouse mammary carcinoma (*MMC*) of the *R*III strain, grafted subcutaneously, was shown to grow progressively in rats, pretreated with some lyophilized mouse tissues of the donor strain, or of genetically unrelated strains[1]. In untreated rats there was no growth. It was later shown that a sarcoma which was induced and transplanted in mice of the *C*57 Black strain (SBL_1) could grow in rats pretreated with lyophilized preparations, either of the sarcoma SBL_1 or of the genetically unrelated carcinoma *MMC*.

In the present work, rats one week old were injected intraperitoneally with a suspension containing 20 mgm. of lyophilized *MMC*, twice weekly for a period of five weeks, and one week later grafted with minced fresh carcinoma *MMC* or sarcoma SBL_1. Sera of these rats were titrated for their ability to agglutinate single-cell suspensions of mouse tumours and of mouse red-blood cells in saline. The single-cell suspensions were obtained by passing solid tumours with the addition of saline several times through a stainless steel gauze (80 mesh, Endecotts, Ltd., London), using the upper part of the suspension after it was left to settle for 30 min. at 4° C. The results were read after a gentle shaking of the test-tube. The intensity of the agglutination expressed itself both by the titre and the size of the clot produced. These varied from a single large pellet to many smaller clots which could not be broken up by shaking. In sera not containing agglutinins the cells settled, but formed a cloudy suspension on gentle shaking.

The results of a study of the sera of rats pretreated and grafted with carcinoma *MMC* (Fig. 1) show that agglutinins against these tumour cells and red blood cells of mice of the *R*III strain reached titres of 1 : 80 to 1 : 320 and 1 : 80 to 1 : 160, respectively, at the end of the pretreatment. Normal untreated control rats of the same sub-line of our inbred strain showed practically no tumour-cell agglutinins, and 50 per cent of them showed low titres of red-blood cell agglutinins. During the growth of carcinoma *MMC*,

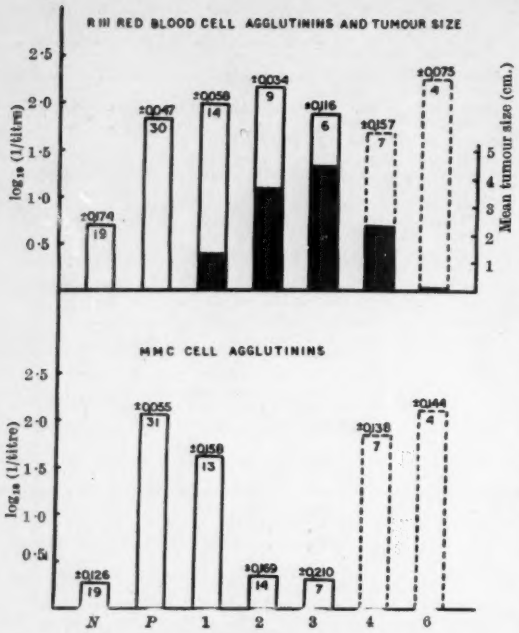

Fig. 1. Changes in titre of agglutinins against carcinoma *MMC* cells and red-blood cells of the *R*III strain of mice, in sera of rats after pretreatment with lyophilized carcinoma *MMC* and during growth and/or regression of the latter.
The dark part of the columns representing the hæmagglutinin titre is the mean tumour size (mean of two diameters in cm.). *N*: sera of normal untreated adult rats. *P*: sera taken at end of pretreatment with lyophilized carcinoma *MMC*. 1, 2 and 3: sera taken one, two and three weeks, respectively, after grafting, during progressive growth of carcinoma *MMC* (solid lines). 4 and 6: sera taken four and six weeks after grafting, during regression of carcinoma *MMC* (broken lines).
The height of the columns represents the mean of the logarithm of the reciprocal of the titres

$$\left(\frac{\Sigma \log_{10} \frac{1}{\text{titre}}}{n}\right)$$

The numbers above each column are the logarithms of the standard error of the mean

$$\text{S.E.} = \pm \sqrt{\frac{\Sigma d^2}{n(n-1)}}$$

The numbers in each column are the number of animals tested in each group (n).

the tumour-cell agglutinins fell to zero in most of the animals within two to three weeks after grafting, when the tumours reached large sizes, and did not rise again when the tumours continued to grow progressively, until the death of the rats. However, in those rats in which the tumour regressed, the tumour-cell agglutinins reappeared in the serum when regression began and reached titres similar to those of the pretreated animals when regression was complete. Such rats were immune to carcinoma *MMC*, in the sense that a second graft failed to grow.

The red-blood cell agglutinins behaved differently; their titre was not affected by either the progressive growth or the regression of the tumour. Thus, there was a clear dissociation of hæmagglutinins and tumour-cell agglutinins in rats bearing heterologous tumours, though both antibodies were at a high level in pretreated or in immune animals.

The disappearance of the carcinoma *MMC* cell agglutinins during the growth of this tumour in pretreated rats could be attributed to: (1) non-specific reduction of the antibody-level by tumour growth[2]; this was unlikely since hæmagglutinins were unaffected and it could be shown that other mouse and rat tumours growing in rats pretreated with lyophilized carcinoma *MMC* did not cause a decrease of *MMC* cell agglutinins; (2) presence of blocking antibodies in sera of tumour-bearing rats[3]; this was also unlikely, since no such antibodies could be demonstrated by the addition of sera of tumour-bearing rats to sera of immune and of pretreated rats; (3) specific absorption of these antibodies by the tumour; this explanation appeared to be the most probable, since *in vitro* absorption of sera of pretreated rats showed that suspensions of carcinoma *MMC* cells completely removed the *MMC* cell-agglutinin titres with almost no change in *R*III hæmagglutinin titres, whereas *R*III red-blood cells completely absorbed hæmagglutinins, leaving the tumour agglutinin titre unchanged.

The behaviour of the hæmagglutinins described above was similar to that observed by Gorer[3] and by Mitchison and Dube[4] concomitant with the pretreatment of mice, and the growth and regression of tumour homografts in such mice. The possibility of a causal connexion between the presence of isohæm-agglutinins and the enhancement of growth of mouse-tumour homografts was discussed by Kaliss *et al.*[5] and by Billingham *et al.*[6].

In the present study the behaviour of the titres of the tumour-cell agglutinins differed from those of the hæmagglutinins, and had a concomitant relation to the growth of the heterotransplant. It could, however, be shown that neither the presence of hæm-agglutinins, nor the presence of specific tumour-cell agglutinins and their absorption by the growing tumour was essential for the growth of the hetero-transplant. Indeed, though the pretreatment of rats with lyophilized carcinoma *MMC* was not followed by the appearance of agglutinins against cells of the sarcoma SBL_1 or against red-blood cells of *C57BL* mice, sarcoma SBL_1 grew as readily as the carcinoma *MMC* in such animals. Sarcoma SBL_1 growing progressively in these rats did not cause any significant decrease in the titres of agglutinins against carcinoma *MMC* tumour cells and the *R*III red-blood cells.

Thus, although in the present heterologous tumour–host combinations, it was possible to demonstrate in sera of rats pretreated and grafted with the same mouse-tumour strain the presence of specific tumour agglutinins and compare their behaviour with that of the hæmagglutinins, none of the serological changes reported above appear to be essential for the growth of a heterograft. It should, however, be noted that the agglutinations were carried out in saline, without the addition of dextran, so that the conclusions apply only to 'complete' antibodies.

We are indebted to Dr. M. Feldman, of the Weizmann Institute of Science, for supplying us with sarcoma SBL_1, which he established. The skilled assistance of Miss Y. Levi is greatly appreciated. Grants by the Helen Ecker Cancer Society and by the Cancer Trustees, London, are gratefully acknowledged.

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LETTERS TO THE EDITORS

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Observation of Short-lived Free Radicals in Solution

THE direct detection of short-lived free radicals by physical methods such as spectroscopy and mass spectrometry has become a valuable means of identification and kinetic study in the gas phase. It has not hitherto been possible to study these radicals in a comparable manner in solution, although radicals which exist in detectable equilibrium concentrations, such as triphenyl methyl, are, of course, readily observed spectroscopically. During our study of triplet states in solution, it was necessary to use purified solvents of high viscosity which had been thoroughly freed from dissolved gases, and we have found that these solvents are suitable for the detection and study of a number of reactive free radicals. The function of such solvents is to retard the diffusion-controlled recombination without offering alternative rapid reactions with the solvent itself.

The solvent which has been found most useful is high viscosity (between 25 and 300 centipoise) paraffin, carefully freed from aromatics and other impurities by separation on a silica column and then thoroughly degassed by successive freezing and evacuation. No free radicals were detectable unless the solvent had been carefully freed from dissolved oxygen. A number of absorption spectra attributed to free radicals has been observed by the flash photolysis of solutions in this solvent. Two examples will be given for which the identification of the spectra is fairly certain and which represent two important classes of aromatic radicals.

(1) *Benzyl and diphenyl methyl.* Flash photolysis of 10^{-3} molar solutions of benzyl chloride in viscous paraffin resulted in the appearance of a transient absorption (Fig. 1) with a maximum at 3175 A., a second maximum at 3060 A. and a decay time of about 2 msec. It was later possible to detect this spectrum in hexane solution at the shortest delay times, but the decay in this solvent was too rapid for kinetic study. An identical spectrum was obtained from benzyl formate and the same bands, with additional absorption due to other species, appeared after photolysis of benzyl alcohol and benzyl methyl ether. The assignment of the spectrum to free benzyl

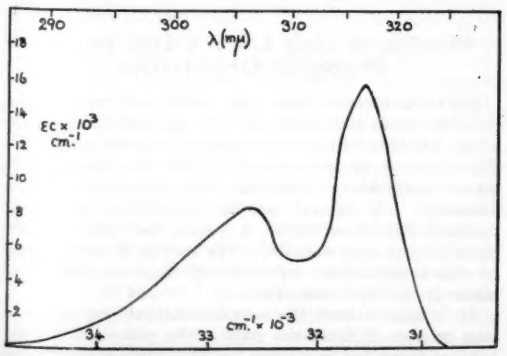

Fig. 1. Absorption spectrum of free benzyl in paraffin solution

is fairly certain when it is compared with absorption spectra of the radical in the vapour phase[1] and in rigid glasses[2], the assignment in the latter case having recently been unequivocably established[3]. The wavelength shifts in solution and in rigid media are typical and well known in other molecules. Photolysis of diphenyl methane gave a similar spectrum with an absorption maximum at 3350 A., and a weaker maximum at 3140 A. which is assigned to the diphenyl methyl radical by comparison with results obtained in rigid media[2,3]. It is worthy of note that, in the vapour phase, the photolysis of diphenyl methane leads to fission of a carbon–carbon bond and production of benzyl. It seems that, although fission of this bond may be favoured energetically, the separation of a hydrogen atom occurs more readily than that of a more bulky phenyl radical in the condensed phases. The absorption maxima in the three phases are :

Molecule	Radical	λ (A.) (solution)	ν cm.$^{-1}$ (solution)	ν cm.$^{-1}$ (gas)	ν cm.$^{-1}$ (glass)
Benzyl chloride Benzyl alcohol Benzyl formate Benzyl methyl ether	Benzyl	3175	31,500	32,760	31,380
Diphenyl methane	Diphenyl methyl	3345	29,900	(benzyl)	29,840

Since reaction of these radicals with hexane and with higher paraffins should not differ greatly, the much lower rate of disappearance in viscous paraffin indicates a diffusion-controlled reaction of which the most probable would be bimolecular collision to form dibenzyl. This interpretation of the reaction is confirmed by our finding that the decay of benzyl is second order. The rate constant in paraffin (η = 163 centipoise) was $7{\cdot}8 \times 10^4 \times \varepsilon$ litre mole^{-1} sec.$^{-1}$, where ε is the extinction coefficient at the 3175 A. maximum.

The benzyl and diphenyl methyl radicals are chemically intermediate between the stable triphenyl methyl and the very reactive methyl radical. Although they dimerize very rapidly, their resonance stabilization results in a relatively high energy of activation for hydrogen abstraction from the solvent, which is probably greater than 15 kcal./mole for benzyl and diphenyl methyl, and it is this which makes their detection possible. The methyl radical, the spectrum of which has recently been detected by flash photolysis in the vapour phase[4], has an activation energy for hydrogen abstraction from paraffins of about 8 kcal./mole, and its life-time in paraffin solution would therefore probably be too short for detection by present techniques.

(2) *Benzosemiquinone.* The flash photolysis of solutions of benzoquinone is followed by a complex series of changes which will be described more fully in a later publication. In viscous paraffin solution the spectrum, immediately after photolysis, consists of two absorption regions, the first with a maximum at 3940 A. and the second with a sharp maximum at 3420 A. and a weaker band at 3310 A. Both absorptions decay with a half-life of a few hundred microseconds, and are shown in Fig. 2.

The maximum at 3940 A. is to be compared with the spectrum obtained in rigid solvents after photolysis both of benzoquinone and hydroquinone[3,5] and attributed to the neutral semiquinone radical. It is to be distinguished from the semiquinone radical-ion, which is relatively stable and can be detected in equilibrium concentration in some quinones though it has not yet been detected in this manner in benzoquinone itself. The neutral radical must be formed

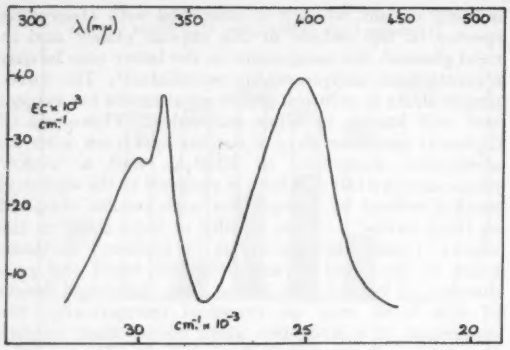

Fig. 2. Absorption spectrum attributed to benzosemiquinone

via the excited quinone molecule by hydrogen abstraction from the solvent, and be stable enough to survive further hydrogen abstraction from the solvent over the period during which it is observed. Its long life in viscous paraffin again indicates a diffusion-controlled bimolecular reaction of removal.

Detailed kinetic studies of these and related radicals in solution are in progress and will be reported later.

We are grateful to the British Rayon Research Association and to the Royal Commission for the Exhibition of 1851 for research fellowships to one of us (M. W. W.) during the tenure of which this work was carried out.

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Point of Attack in Hydrocarbon Oxidation

A conflict apparently exists between the aldehyde degradation mechanism indicated by the recent findings of Bailey and Norrish[1] and of Knox and Norrish[2], on one hand, and the preferential attack at the tertiary and secondary carbon atoms deduced, indirectly, by Walsh[3], Boord[4] and Badin and Pease[5]. A possible solution is provided by some recent studies, by gas-phase chromatography, of the products of slow oxidation of *n*-heptane, in a flow system. Although no tests for formaldehyde were made, aldehydes from C_2 to C_6 were detected at 300° C.; at 280° C., however, the extent of reaction was very small, and the only products condensed at − 80° C., apart from traces of peroxides, consisted of propionaldehyde and *n*-butyraldehyde. This suggests that the initial attack is at one of the secondary carbon atoms, with subsequent fission of one of the central C—C bonds. The more reactive chain carriers formed during this process can then attack the primary carbon also, and lead to the formation of higher aldehydes.

This deduction is supported by preliminary results obtained during studies of the partial, slow reaction of mono-deuterated propanes with a small proportion of oxygen. By carrying out kinetic studies, *in situ*, on an infra-red spectrometer (Burt and Minkoff[6]), conditions were selected which avoided fission of the C—C—C skeleton. The deuterium content of the liquid products was then determined, using an infra-red method. From experiments with $CH_3D.CH_2.CH_3$ and $CH_3.CHD.CH_3$, and making some assumptions which are discussed below, it was deduced that at 360° and at 420° C., attack on the secondary C—H or C—D bond was at least 1·9 times faster than that on the corresponding primary bond.

Two of the assumptions are not likely to affect the conclusions appreciably. The first is that the relative amounts of OH and OD bonds formed are proportional to the rates of attack at each CH and CD bond in the original molecule, and the second involves the supposition that there is little, if any, difference in the isotope effect on the rate at the different positions. The third possible source of error requires more detailed consideration: at first sight, it might be expected that the formation of propylene from a propyl radical must involve the loss of hydrogen from a carbon adjacent to that at which attack initially occurred. Thus, if both steps involve oxygen, the deuterium content of the water should not permit an experimental distinction. However, it can be shown that if this were true the D : H ratios would differ considerably from those which were observed. It must therefore be deduced that the formation of propylene from the propyl radical, under the present conditions of large excess of hydrocarbon, involves reactions with radicals or molecules which contain no oxygen. Further experiments are in progress to confirm and extend these results.

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Micelles of Long Life: a Step towards Biological Organization

Investigations into the state of solution of paraffin-chain salts have usually ignored the question of the life-time of the individual aggregates (micelles)[1]. Their size is known to be limited, and they are in strict equilibrium with the free long-chain ions in solution[2]. It would appear to follow that their number fluctuates about a mean, and that the life-time of any one micelle, while small, is not capable of exact definition, especially if there is a range of sizes up to the maximum.

It is known that the size limitation may apply to one or two dimensions only; the presence of very large aggregates is shown by the high viscosities of

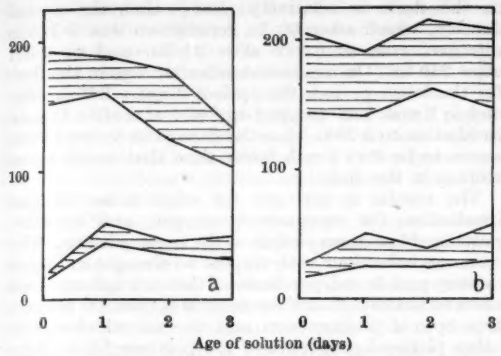

Fig. 1. Apparent specific viscosity at 20° of two states of a polymicelle solution: upper region, high-viscosity solution; lower region, low-viscosity solution. Rate of shear, about 1 sec.$^{-1}$. (*a*) Cetyl trimethyl ammonium bromide/1-naphthol/salt. (*b*) Cetyl trimethyl ammonium bromide/2-naphthol/salt

dilute solutions of some paraffin-chain salts[3]. There is general agreement that such behaviour is due to linear micelles; Halsey[4] has given theoretical reasons for their stability. Evidence is now available that some of these 'polymicelles' can be so long-lived as to have virtually a permanent individual existence.

In experiments with dilute solutions of cetyl trimethyl ammonium bromide and either of the naphthols, it had repeatedly been noticed that the viscoelasticity depended not only on the composition but also on the way the solution was made up[5]. Particularly striking were the differences observed in the rates of foam drainage[6]. To confirm this effect by more conventional methods, measurements were made in a Couette-type viscometer, such as was used by earlier workers[3]. Two systems were investigated, cetyl trimethyl ammonium bromide/1-naphthol/sodium bromide and cetyl trimethyl ammonium bromide/2-naphthol/sodium bromide, 0·5, 0·5 and 1·0 m*M* in water, respectively. A low-viscosity solution resulted when the order of addition was *M*/20 alcoholic naphthol, *M*/20 aqueous salt and *M*/20 aqueous cetyl trimethyl ammonium bromide; a high viscosity one when the order was cetyl trimethyl ammonium bromide, naphthol, salt. The results are shown in Fig. 1, samples being taken on successive days to show the stability of the individual states. Because of the characteristic fluctuations in the reading, a range is shown, covering the last 30 min. of a 60-min. run, or 180 revolutions of the cup, every day.

No analysis is needed to see that each solution exists in two different states. If molecular aggregates were continually forming and disappearing, there could be only one state; it follows that these polymicelles are permanent structures, low-viscosity solutions having more but smaller ones than high-viscosity solutions. Momentary heating to 40° destroys all trace of viscoelasticity, but the two states reappear on cooling. Momentary heating to 50° converts a low-viscosity solution to a high-viscosity solution, the latter remaining unchanged. Loss of individuality with such mild treatment indicates that the polymicelle is only just complex enough to exhibit the new property. Its structure has been discussed elsewhere[5]; an essential factor is thought to be π-electron interaction between neighbouring parallel aromatic molecules[7] adsorbed on to the outside of the cationic micelle. The compatibility of a permanent structure with the free diffusion of its components is of theoretical importance, and it is hoped that a study of these relatively simple systems will help in the understanding of the formation and activity of physically unstable biological aggregates such as β-lipoprotein.

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Photochemistry of Polymer Films

Ford[1] has reported that when nylon polymer films are irradiated in the presence of oxygen, a new absorption band develops around 2900 A., which increases in intensity on storage in the dark and is reduced on re-irradiation to about the pre-storage value. His explanation of this phenomenon with nylon films was that oxygen was directly responsible for this effect. We have recently been investigating this stepwise 'post-irradiation effect' and have found that it occurs with several other polymer films, is no less prominent in nitrogen than in oxygen, and is not restricted to a particular absorption band. It therefore seems doubtful whether these changes in absorption spectra are the result of the reaction of the polymer with oxygen.

The chemical changes produced in polymer films on irradiation are undoubtedly complex. In some of our experiments we have exposed transparent films of cellulose (deplasticized, British Cellophane, Ltd., *PT*300, 0·00085 in. thick) and cellulose acetate (deplasticized, British Celanese, Ltd., 0·001 in. thick) to the radiations from a low-pressure mercury-vapour lamp emitting mainly at 2537 A. During these experiments streams of dry oxygen or dry nitrogen (oxygen-free) were passed through the quartz cells in which the films were contained and in which absorption measurements were made. As is clear from Fig. 1, the optical density of the two films increases much more in nitrogen than in oxygen, and it has been found that this difference between the results in the two gases increases with longer times of exposure. However, we have also found that films of nylon (polyhexamethylene adipamide) and its N-methoxylmethyl derivative behave differently, and here the optical density of the film is somewhat greater after irradiation in oxygen than in nitrogen, although the effect of irradiation in the latter gas is by no means insignificant.

The changes in other properties of the polymer films do not seem to be closely connected with the results of absorption measurements. Thus, the nylon-type polymer films showed the greatest increase in optical density for a given exposure, whereas the changes in the plastic properties of the films seemed relatively quite small. The cellulose-type films showed smaller changes in absorption on irradiation but more rapid deterioration of film-like properties. In the latter respect, the changes were significantly greater

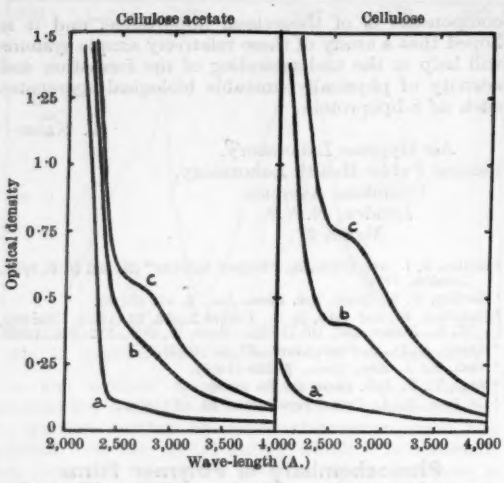

Fig. 1. Films of cellulose and cellulose acetate exposed to low-pressure mercury-vapour lamp at 35° C.: (*a*) unexposed; (*b*) exposed 200 hr. in dry oxygen; (*c*) exposed 200 hr. in dry nitrogen

in oxygen than in nitrogen. After irradiation for 270 hr. in dry oxygen, the cellulose acetate film collapsed to a fine powder, whereas even after 500 hr. the film exposed in dry nitrogen still retained the character of a film although it was very brittle on removal from the quartz cell. Likewise, the cellulose film was slightly less brittle after irradiation in nitrogen than in oxygen.

On storage in the dark after irradiation, the optical density of all these films increases, possibly as the result of the slow combination of free radicals trapped in the polymer. The resultant products are presumably broken down again on re-irradiation. These changes are produced in either oxygen or nitrogen, and would seem to be largely independent of the atmospheric conditions. Typical results are shown in Fig. 2 for cellulose acetate film which was irradiated in dry nitrogen and dry oxygen, stored in the dark in the same gas, and afterwards re-exposed. The results are recorded at one particular wave-length (2600 A.), but at wave-lengths near this the results were qualitatively the same. The change on storage

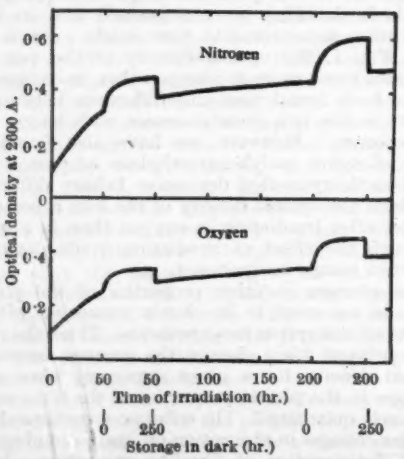

Fig. 2. Effect of storage and re-exposure on optical density of irradiated cellulose acetate film (all treatments at 35° C.)

in the dark is relatively slow; thus the optical density, which after 50 hr. irradiation was 0·316 in nitrogen, rose to 0·389 after 24 hr. and to 0·441 after 250 hr. On irradiation after storage in the dark for the latter period, the optical density fell rapidly, and in 2 min. had dropped to 0·410 and after 10 min. irradiation to 0·388. Thus the change on re-irradiation seems to be very much faster than that occurring on storage in the dark.

The results in nitrogen for other times of prior irradiation, for exposures in oxygen, and for other polymer films seem to follow the same pattern. This common behaviour with respect to changes in optical density and its independence of the atmosphere would seem to indicate that there is little connexion between this optical phenomenon and the actual change in other physical properties of the polymer film. Moreover, in confirmation of the greater deterioration of the plastic properties of cellulose acetate film in oxygen, it is known[2] that the tendering of cellulose acetate rayon yarn is much greater when irradiated with a low-pressure mercury lamp in oxygen than in nitrogen.

It would not seem unreasonable to suppose that on irradiation these polymer films give rise to free radicals, which only slowly recombine because of the limitations of movement in the polymer mass. On storage in the dark some recombination with themselves or the polymer occurs, but the compounds so produced are very susceptible to photolysis, and on further irradiation the process is reversed and the free radicals reformed.

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March 26.

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A Moving-Paper Collector for Column Chromatography

Dewar and Gunew[1] have described the use of a serrated glass strip as a collector for column chromatography. In this laboratory a method has been developed in which a moving strip of paper is used for the same purpose.

The advantages of this method are its simplicity, its sensitivity to drop-by-drop changes of composition and concentration in the eluate, and its presentation of the eluted compounds in series on paper where they may be identified or estimated with the normal reagents of paper chromatography.

The apparatus (Fig. 1) consists of a kymograph motor and drum, two rubber-covered rollers on which the drum rests, and a further pair of rollers which serve to maintain a slight tension on the filter paper strip.

A strip two inches wide is drawn by the revolving drum from a freely suspended roll of paper, through the paired rollers and under the dripping point of the

Fig. 1

chromatographic column at the minimum speed consistent with the collection of separate drops.

The spots, which dry as they are carried along, are then treated with suitable reagents. The development of ninhydrin colours with amino-acids can, for example, be achieved by passing the dried paper through a solution of that reagent in acetone and a heated 'tunnel' as illustrated in Fig. 1. For quantitative determinations a photoelectric scanner may also be placed in series.

When a limited number of drops are to be collected, a continuous strip of filter paper passing around two drums is adequate for the purpose. A wider paper is recommended for this method, as it is then possible to move the dripping point at the end of each completed circuit, and continue the collection of drops in parallel lines without changing the paper each time.

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Variation of the Horizontal Force near the Magnetic Equator

Since November 1955 a magnetic observatory has been in operation at University College, Ibadan (lat. 7° 26′ N., long. 3° 54′ E.), 2° 34′ south of the magnetic equator. Between November 25, 1956, and January 22, 1957, photographic recordings of the variation of the horizontal component H of the Earth's magnetic field were made for a period of a week at each of nine field stations between lat. 6° 36′ N. and 13° N.; that is, between about 3° north and 3° south of the magnetic equator. Records were taken with a simple temperature-compensated variometer, and were supplemented by frequent *QHM* readings. The whole period was relatively quiet magnetically, and the records at all stations included a number of quiet days.

The daily range of H, taken as the difference between the mean values for an hour around the times of maximum and minimum, was found for each station, and compared with that for the base station at Ibadan. Although the ratio of the ranges at the field and base stations varied considerably from day to day, the mean value of the ratio shows a smooth variation with latitude.

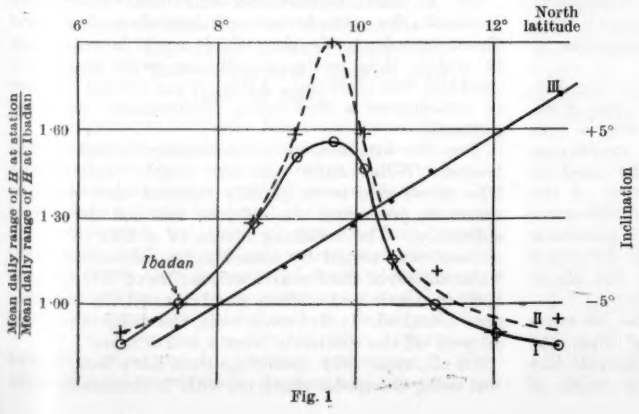

Fig. 1

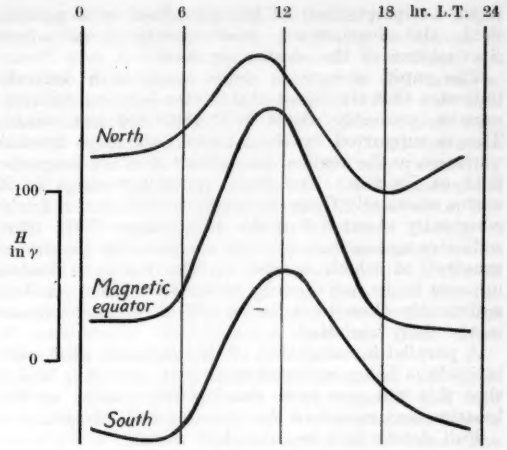

Fig. 2

In Fig. 1, curve I shows the mean of the ratio for quiet days, curve II for all days, and curve III the magnetic dip, against latitude in each case.

It is clear that, at the December solstice at least, the region of maximum range of H is about 0·5° south of the magnetic equator. The curve shows some asymmetry about this maximum. Under quiet conditions the maximum range is about 1·8 times that at stations only 3° to the north or south.

The form of the daily variation curve also varies markedly with latitude. Fig. 2 shows this, each curve being the mean of six days. South of the magnetic equator there is a rapid rise from a minimum at about 0500 hr. (local time) to a maximum at 1200 hr., followed by a slow decline; close to the magnetic equator the curve is symmetrical with a maximum at 1100 hr.; and to the north there is a slow rise from midnight to a maximum at about 1000 hr., followed by a rapid decline to a minimum at about 1800 hr.

If the degree of asymmetry A is expressed as the difference between the values at 0500 and 1800 hr. divided by the daily range, A is found to vary linearly with latitude.

It does not seem possible to explain these changes in the form of the daily variation curve in terms of a lunar influence on a solar diurnal variation. It is suggested that a satisfactory explanation can be found in the superposition of the effects of a narrow equatorial electro-jet, localized at the magnetic equator or very near it, on a more general field which varies appreciably with latitude in phase and probably in magnitude.

On many occasions even on quiet days, fluctuations in H are observed which are coincident in time and similar in form at the base- and field-stations; these appear similar to those reported by Chapman and Bartels[1]. The amplitude of these fluctuations at a station 0·5° south of the position of maximum daily range has a mean ratio of 1·80 to that at the base-station. As this is higher than the ratio of the daily ranges at the stations, it suggests that whereas the daily range may result

from a superposition of the jet effect on a general field, the fluctuations arise mainly from minor fluctuations of the electro-jet itself.

The rapid change in daily range with latitude indicates that the equatorial electro-jet must be very narrow, probably about 2–3° (200–300 km.) wide. This is supported by the anomalously large diurnal variation in the vertical component Z of the magnetic field at Ibadan. The mean quiet-day range in Z varies seasonally from about 40γ to 80γ, and is fairly constantly about 0·6 of the daily range of H. This indicates an origin in a current system the 'centre of gravity' of which is well to the north. Ibadan appears to be not directly under the electro-jet, but sufficiently close to it for its effects to predominate in the daily variation.

A parallel investigation of the variation of Z with latitude is being undertaken shortly, and it is hoped that this will give more detailed information on the location and extent of the equatorial electro-jet.

Full details will be published shortly.

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A Frequency Comparator using Electron and Proton Resonance in a Common Magnetic Field

High microwave frequencies may, with advantage, be measured by utilizing electron and proton paramagnetic resonances in a common magnetic field. For this purpose the free radical diphenyl trinitrophenyl hydrazyl, which has one of the strongest and narrowest lines yet reported[1], is suitable for the electron resonance sample. The protons in water containing a trace of a paramagnetic salt provide the most suitable substance for the proton resonance.

The method of frequency measurement at, say, 35,000 Mc./s. is as follows. The magnetic field is varied until a signal is observed from the electron resonance. This will be at about 12,000 gauss. This field is then measured by means of a proton resonance fluxmeter. If the common magnetic field is swept through a small range in synchronism with the X-deflexion of a cathode ray tube, it is possible to superimpose the proton and electron signal with considerable precision despite small instabilities in the magnetic field.

When this has been done the ratio of the two frequencies depends on the ratio of the two gyromagnetic ratios $\gamma_e/\gamma_p \simeq 658{\cdot}5$. In this way a conventional high grade signal generator employing quartz crystal calibration points may be used to read the lower frequency; and by means of the multiplying factor 658·5, converted to the microwave frequency. Alternatively a quartz harmonic generator may be used, of fundamental frequency $10^n/658{\cdot}5$ Mc./s., and this will provide markers at 10^n Mc./s. intervals, where n is a convenient integer.

The accuracy of the system has yet to be more fully investigated, but it would appear that the most fundamental limitation is the rather wide line of polycrystalline hydrazyl. This has a width of 8 Mc./s. so the setting accuracy would be of the order of 0·8 Mc./s. However, there may be better materials available, such as aminophenyl-aminium perchlorate, which is reported[2] as having a line width of about 1 Mc./s. Sodium in ammonia[3] could also be used but has practical difficulties. Its line width is reported as about 0·2 Mc./s. Another very practical limitation is the uniformity of the magnetic field required to render the field common to both specimens in space (or the stability required for the exchange to take place in time). The most promising method would appear to be to exchange the relative positions of electron and proton sample and take the mean of two or more observations. It is expected that the accuracy to which γ_e/γ_p is known will improve as work proceeds.

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Use of 'Nobecutane' in attaching Skin Electrodes

In routine physiological experimentation, various types of electrodes are used attached to the surface of the body. These are commonly attached by rubber bands, strips of adhesive plaster or some kind of cement. At the R.A.F. Institute of Aviation Medicine, three types of electrode are being used which require a special method of attachment.

(1) For routine electrocardiograms in the acceleration research department, small silver disks 1·5 cm. in diameter are used attached to the front of the chest for the V-leads and to the back for the Duchosal and Sulzer method in vector cardiography. Contact with the skin is limited to the circumference of the disk, the centre position being recessed and containing electrode jelly. These electrodes and their leads are subjected to fairly severe strain when the subject is having accelerations of up to 7G applied. An adhesive was required which would hold the electrode firmly in position and yet allow movement of the part and withstand a fair pulling strain.

(2) In the climatic research unit, experiments required the attachment of heat-flow disks and thermocouples to the skin which would be submerged in water, thus a strong adhesive with waterproof qualities was essential. After trying several methods of attachment a trial using 'Nobecutane' was commenced.

For the attachment of electrocardiographic electrodes, 'Nobecutane' proved highly satisfactory. The electrodes were quickly applied and the time spent in preparing the subject was cut down considerably. The breaking strain of a film of 'Nobecutane' was tested by attaching an electrode to the volar aspect of the forearm with a film of 'Nobecutane' 0·01 in. thick and adding weights until the electrode was detached. In five such tests, the weights required to pull off the electrode were 2·0–2·5 kgm.

In all, some fifty centrifuge runs have been carried out using electrodes stuck on with 'Nobecutane' with-

out any pulling off. Some subjects have had electrodes attached to the flexure at the elbow for two days while performing their normal work and washing without any detachment. The best method of attaching the electrodes has been found to be by painting the circumference of the disk with 'Nobecutane' solution and fixing to the skin; when this has dried, the whole is given a film of 'Nobecutane', using the spray.

The experiments utilizing heat-flow disks and thermocouples required from six to eleven of each type of electrode to be attached to a subject, who was then immersed in a bath of water (temperature, 34–40° C.) for a period of 2–3 hr. The method used to attach the heat-flow disks was to place them in contact with the skin, cover with a layer of gauze and spray the latter with 'Nobecutane', thus leaving the heat-flow disk in a waterproof compartment. The thermocouples were placed in contact with the skin and 'Nobecutane' sprayed over them. To date, sixty such experiments have been carried out without detachment of any electrodes and there was no evidence of any leak of water. In some instances the thermocouples were covered with a pad of dry cotton-wool before being sprayed with 'Nobecutane' and at the termination of the experiment the cotton wool was still dry. An interesting point is that submersion of the subject before drying of the 'Nobecutane' made little difference in that the electrodes remained dry and attached.

Only one skin reaction has occurred in the series. This was a local urticarial reaction at the site of attachment of the electrocardiogram electrodes. However, when this subject was afterwards scratched with electrode jelly alone, a similar reaction occurred; thus it is unlikely the reaction is due to 'Nobecutane'.

Hence, it appears that 'Nobecutane' is a very satisfactory material for the rapid attachment of electrodes which are required to withstand strain, while for underwater electrodes it is the only substance so far encountered which will fulfil the necessary requirements.

The 'Nobecutane' for this trial was kindly supplied by Messrs. Evans Medical Supplies, Ltd.

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Influence of Post-Irradiation Administration of Methionine on the Levels of Deoxyribonucleic Acid in Bone Marrow, Spleen and Liver of Rats

Experimental evidence has been accumulating in recent years to suggest an important role of methyl groups in the formation of nucleic acids. Among the principal sources of methyl groups for the animal organism are methionine and choline. The organism can synthesize the methyl groups from simple precursors, such as glycine, serine and 'formate'[1]. Studies from this laboratory[2] have demonstrated that methionine, which contains an active *S*-methyl group, is very radiolabile and is destroyed both in the *in vivo* and in the *in vitro* experiments, following exposure to ionizing radiations. Post-irradiation administration of spleen and bone marrow homogenates has been found to counteract the lethal and other biological effects of ionizing radiations in mice[3], and it has been postulated[4] that these act through a humoral agent present in the extracts. In view of these findings, coupled with our own results on radiolability of methionine, it was considered necessary to investigate if post-irradiation administration of methionine offered any protection at all against radiation exposures. Since impairment of nucleic acid synthesis following X-irradiation has been well established[5], any substance having a modifying influence on the primary radiation lesion should have a beneficial influence on the levels of nucleic acids. This criterion has been used here to assess the possible protection and therapeutic effects of methionine administered half an hour after total-body X-irradiation.

The experimental animals consisted of male Wistar albino inbred rats 2–2½ months old and weighing 200–250 gm. These were maintained on a standard laboratory diet and water *ad libitum*. The rats were given a single total body X-irradiation of 600 r., dorsal and ventral sides getting 300 r. each. A 'G. E. Maximar' deep-therapy unit, operated at 220 kV. and 10 m.amp. with 0·5 mm. copper and 1·0 mm. aluminium filters, was used for irradiating the animals. The distance of the animals from the target was about 35 cm. and the dose-rate was 50 r./min. in air as determined by a Victoreen dosimeter.

The rats were divided into five groups of six animals each. The first group served as controls, whereas the second group received methionine only (without irradiation) and the third group received 600 r. total-body X-ray irradiation only. In the second group, an aqueous solution of methionine (1 mgm./ml.) was injected intraperitoneally in a single dose of 5 mgm./kgm. body-weight, 24 hr. before killing. The animals of the fourth and fifth groups received total-body irradiation and in addition received 5 mgm./kgm. body-weight of methionine intraperitoneally 30 min. after and before irradiation respectively. The irradiated groups (3, 4 and 5) were killed 24 hr. after X-irradiation. Food was withheld overnight prior to killing in controls as well as in experimental animals. The rats were killed by ether inhalation, and the liver, spleen and bone marrow quickly dissected out and nucleic acids estimated by Schneider's modification[6] of Schmidt and Thannhauser's method[7], as described by Baxi *et al.* (*loc. cit.*). Phosphorus determinations were carried out by Fiske and Subbarow's method, as modified by LePage and Umbreit[8].

The results, giving the levels of deoxyribonucleic acid in liver, spleen and bone marrow in irradiated and methionine-treated irradiated rats, are given in Table 1. It will be noticed that the total-body X-irradiation brings about a fall in levels of deoxyribonucleic acid in all the tissues studied and that

Table 1. Influence of Administration of Methionine on the Levels of Deoxyribonucleic Acid in Bone Marrow, Spleen and Liver of Irradiated Rats

Nucleic acids expressed as mgm. P/100 gm. wet weight

Group	Liver	Spleen	Bone marrow
Controls	19·40	95·50	256·0
Methionine group	17·30	89·60	228·0
X-irradiated group	16·80	26·90	31·60
X-rays + methionine (½ hr. after)	23·80	46·20	126·6
X-rays + methionine (½ hr. before)	23·20	37·30	89·3

the administration of methionine either before or after irradiation is able to check the fall to some extent. Post-irradiation administration of methionine, however, appears to be more effective in this respect. The fall in level of deoxyribonucleic acid in post-irradiation methionine-treated animals was 50·6 and 51·6 per cent respectively in bone marrow and spleen. The corresponding figures for irradiated animals without the methionine treatment of group 3 were 87·9 and 71·8 per cent. The fact that the post-irradiation administration of methionine is more effective in arresting the fall in nucleic acids levels caused by exposure to radiation than the pre-irradiation treatment can be explained on the basis of the radiolability of methionine reported previously[2].

In a previous communication from this laboratory (Baxi *et al.*, *loc. cit.*), it was suggested that irradiation causes depletion of nucleic acid levels in two ways: (1) by destruction of preformed cells with a consequent catabolism of nucleic acids contained in them; and (2) by impairment of the nucleic acid synthesizing mechanism itself. Methionine has been known to play a dual part in the body, first by aiding transmethylation processes, and secondly by participating in the synthesis of creatine and thus influencing the process of phosphorylation. Since both these processes are vital for the synthesis of nucleic acids, it appears likely that replacement of methionine helps in keeping the nucleic acid synthesizing mechanism in order and thus exerts a therapeutic influence on radiation injury.

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Effect of Angiotonin on the Distribution of Sodium, Potassium and Water in the Rat

Studies of 'Pitressin' in the bilaterally nephrectomized rat have shown that this extract causes a shift of sodium and water out of the extracellular fluid while potassium moves in[1]. These movements are related to the pressor effect of the extract. Similar shifts are also associated with the pressor effects of epinephrine and norepinephrine[2,3]. With all these agents, reverse shifts occur during the decline of the blood pressure back to normal. Based on our interpretation of these and other similar experiments, we have suggested the theory that the regulation of blood pressure depends, *inter alia*, on the sodium transfer systems[4]. We have considered potassium to be of less importance than sodium in this regulation, since shifts of this ion are usually considerably less in total amount. This idea is supported by the present findings with angiotonin (hypertensin) in which sodium shifts were not accompanied by any inverse shift of potassium.

The pressor effect of angiotonin is known to be magnified by previous (at least 24 hr.) nephrectomy. Thus, all rats in these experiments were bilaterally nephrectomized and only 24 hr. later received inulin (12 mgm./100 gm., for measurement of extracellular fluid volume) intravenously. After two hours of equilibration, a basal femoral artery blood sample (0·6 ml.) was obtained, the test agent injected and two further blood samples taken. Samples were analysed chemically for inulin[5] and for sodium and potassium by flame photometry. A continuous femoral artery blood-pressure was recorded electromanometrically.

In the first experiment, 10 units of angiotonin in 0·2 ml. of saline was infused over a 30-sec. interval in a test group of 10 rats; saline alone in 10 controls. The second blood sample was drawn 20 sec. after the start of the infusion while the pressure was rising, the third at 50 sec., at the peak of the pressure curve. The second experiment was identical except that blood was drawn at 80 and 120 sec., on the falling curve of pressure. Fig. 1 shows that blood pressure and extracellular sodium form inverse curves. Potassium did not shift.

The third experiment was similar except that 50 mU. 'Pitressin' was infused. The second blood sample was taken at 50 sec., the third at 90 sec.—points on the rising curve of blood pressure comparable with those in the first angiotonin experiment. Table 1 compares the results with 'Pitressin' and angiotonin. Both agents clearly shift sodium and water out of extracellular fluid but differ in their effect on potassium since this ion is unaffected by

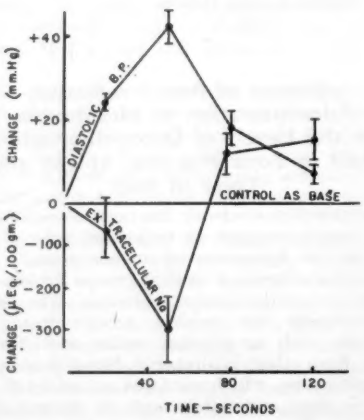

Fig. 1. Effect of 10 U. of angiotonin infused intravenously in 30 sec. on diastolic blood-pressure and calculated extracellular sodium in nephrectomized rats. Standard error is indicated by verticals

Table 1. Shifts of Sodium, Potassium and Water (with Standard Error) measured during the Rise of Blood-Pressure induced by Angiotonin or 'Pitressin' in the Rat. The Second Interval chosen for each Agent approximates to the Time at which Peak Pressure was Attained

		Angiotonin		'Pitressin'	
		0–20 sec. change	0–50 sec. change	0–50 sec. change	0–90 sec. change
Diastolic blood pressure (mm. mercury)	C	0 ± 1	− 4 ± 1	− 1 ± 1	− 8 ± 2
	T	+ 24 ± 2*	+ 38 ± 4*	+ 68 ± 2*	+ 75 ± 2*
Extracellular fluid volume (ml./100 gm.)	C	+ 0·58 ± 0·30	+ 0·10 ± 0·46	+ 0·26 ± 0·65	− 0·41 ± 0·65
	T	+ 0·44 ± 0·54	− 1·16 ± 0·49	− 0·27 ± 0·64	− 0·80 ± 0·45
Plasma sodium (m.equiv./l.)	C	+ 0·1 ± 0·8	− 1·1 ± 0·7	− 0·7 ± 0·3	− 0·5 ± 0·7
	T	− 0·9 ± 0·8	− 3·6 ± 1·3*	− 2·2 ± 0·5†	− 4·0 ± 0·4*
Plasma potassium (m.equiv./l.)	C	− 0·29 ± 0·06	− 0·26 ± 0·07	− 0·37 ± 0·10	− 0·44 ± 0·11
	T	− 0·36 ± 0·10	− 0·25 ± 0·01	− 0·09 ± 0·10	+ 0·27 ± 0·10*
Extracellular sodium (μequiv./100 gm.)	C	+ 105 ± 45	− 14 ± 70	+ 18 ± 85	− 19 ± 74
	T	+ 42 ± 78	− 315 ± 84*	− 96 ± 97	− 215 ± 70†
Extracellular potassium (μequiv./100 gm.)	C	− 4 ± 1	− 6 ± 2	− 8 ± 2	− 13 ± 4
	T	− 7 ± 2	− 13 ± 2	− 2 ± 2	+ 2 ± 3*
No. of animals	C	10		9	
	T	10		9	

C = control. T = test.
* $p < 0.02$ for datum marked.
† $p < 0.05$ for datum marked and < 0.02 on pooling both intervals.

angiotonin. Similar results have been obtained with vasoactive drugs in the dog, supporting our conclusion that sodium shifts are intimately concerned with blood-pressure regulation.

We are grateful to the Ciba Co., Ltd. (Montreal), for support of this project. The angiotonin was generously supplied by Dr. F. M. Bumpus, the 'Pitressin' powder by Dr. D. A. McGinty (Parke, Davis and Co.).

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Metabolism and Metabolic Effects of Thyroglobulin

Injection of beef or hog thyroglobulin into experimental animals causes an increase in basal metabolic rate and antagonizes the action of antithyroid drugs. These effects are similar to those following the injection of thyroxine. There is yet no adequate explanation for the fact, reported by various workers[1], that these thyroglobulins are more effective than can be accounted for by the liberation in the body of the thyroxine they contain. More recent observations have demonstrated the varying ability of different species to remove homologous and heterologous thyroglobulins labelled with iodine-131 from the circulation[2]. An attempt is now being made to correlate the metabolism of different thyroglobulins with effect on the basal metabolic rate at the same dose-level. This communication concerns the absorption, metabolism and metabolic effects in the rabbit of purified dog thyroglobulin.

The thyroglobulin was prepared by fractional precipitation of gland extracts with ammonium sulphate, the final solution being freeze-dried. For use it was diluted with a suitable amount of similarly purified material, labelled *in vivo* by administration of iodine-131. The relevant analytical data were as follows:

Iodine content (Leipert method) 0·6 per cent
Iodinated components (determined by a combination of proteolysis and chromatography)

Thyroxine	14·0 per cent
Tri-iodothyronine	1·7 ,,
Di-iodotyrosine	47·0 ,,
Mono-iodotyrosine	33·0 ,,
Iodide	3·5 ,,
Unhydrolysed material	1·8 ,,

Fig. 1 shows the plasma levels of radioactivity after administration of the labelled dog thyroglobulin (50 mgm./kgm.) by various routes, and Fig. 2 represents the corresponding effects on the basal metabolic rate. Absorption of the protein from the peritoneal cavity was rapid (95 per cent of the dose appeared in the plasma after 5 hr.) and the rate of clearance of radioactive material from the blood thereafter was similar to that following intravenous injection (Fig. 1). From a subcutaneous site, however, radioactive protein entered the circulation at a very slow rate, so that a peak value of about 30 per

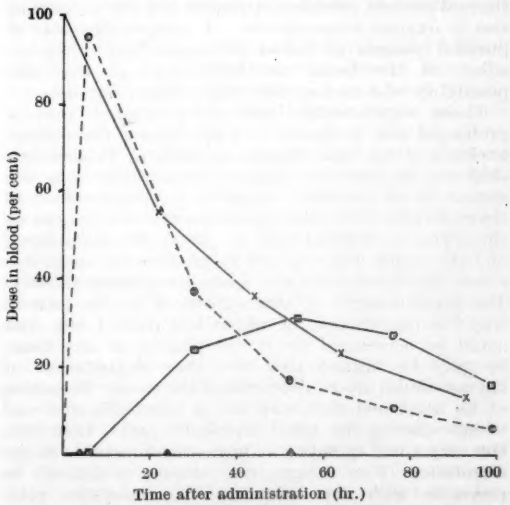

Fig. 1. Plasma levels of radioactivity in rabbits after administration of labelled dog thyroglobulin (50 mgm./kgm.) by various routes: × - - - ×, intravenous; □—□, subcutaneous; ○—○, intraperitoneal; △—△, oral

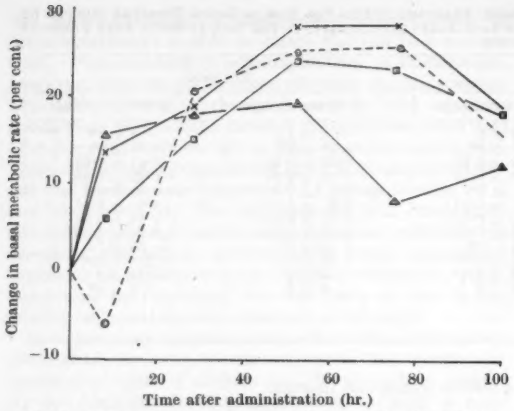

Fig. 2. Changes in the basal metabolic rate produced in rabbits by dog thyroglobulin administered by various routes: ×——×, intravenous; □——□, subcutaneous; ○- - - ○, intraperitoneal; △——△, oral

cent of that injected was present in the blood two to three days later. No radioactive protein appeared in the plasma from the oral route—indeed the maximum amount of radioactivity found in the circulation (at 4 hr.) was less than 0·4 per cent of the dose given, and consisted of a mixture of iodide and thyroxine (3 : 1). After parenteral administration, however, the circulating material remained indistinguishable from thyroglobulin using paper chromatography, and only traces of metabolites (iodide and thyroxine) were detected. Since the rabbits were not thyroidectomized, a proportion of the minute amount of labelled thyroxine present must have been due to a turnover of radioactive iodide by the gland. On the whole, the basal metabolic rate rise began on the day of administration of the thyroglobulin (Fig. 2). After intravenous, intraperitoneal and subcutaneous injection, the course of events was very similar, with a maximum increase of 25–30 per cent in about two days, slowly declining after three to four days. Oral administration of the thyroid protein produced a similar but less consistent rise in oxygen consumption. A comparable dose of purified plasma globulins (50 mgm./kgm.) had no effect on the basal metabolic rate, so that the possibility of a non-specific effect seems remote.

These experiments have demonstrated that a prolonged rise in metabolic rate follows the administration of dog thyroglobulin to rabbits. It is curious that the increase in oxygen consumption does not appear to be directly related to the plasma-level of thyroglobulin or to the liberation into the plasma of the thyroxine derived from it. About 0·5 mgm./kgm. of L-thyroxine was required to produce a comparable rise in basal metabolic rate when given intravenously. The total amount of this substance in the protein was 0·1 mgm./kgm., of which less than 1 per cent could be accounted for in the plasma at any time. It may be argued that the slow degradation of thyroglobulin after injection and the steady liberation of its combined thyroxine are a more effective way of stimulating the basal metabolic rate. However, the very small quantity of hormone detectable in the circulation (2 or 3 μgm. per animal) is difficult to reconcile with the effect on the metabolic rate. Moreover, the minute proportion of labelled thyroxine in the plasma persisted while the metabolic rate returned to normal levels.

Detailed results of these experiments and of studies with other thyroglobulins will be published elsewhere.

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An Acetylcholine-like Salivary Poison in the Marine Gastropod *Neptunea antiqua*

In *Neptunea antiqua* the salivary glands are large organs weighing 1–3 gm. (Fig. 1). The fresh glands have a peculiar intense smell, probably due to the presence of volatile amines. Extracts of the glands (made with water, acetone or ethanol) have a strong contracting effect on smooth muscle. When a dose corresponding to about 1 : 100 of a gland was injected into small fishes (*Ctenolabrus*, *Gadus*) or mice, the animals died within a few minutes. When somewhat smaller doses were injected intraperitoneally into mice, the animals survived but developed symptoms of heavy stimulation of the parasympathetic system: a profuse secretion of saliva and tears. The secretion could be abolished by atropine. Glandular extracts were tested on the heart of *Cyprina*[1] or the isolated radula-muscle of *Buccinum*[2] and were found to produce acetylcholine-like effects corresponding to a concentration of acetylcholine of about 10^{-8} gm./ml. Unlike acetylcholine solutions the extracts did not lose their physiological effects by short boiling at *p*H 9 or by the addition of acetylcholine esterase (a drop of human blood). Paper chromatography showed a very distinct spot which was stained brick-red by dipicrylamine[3] and had an R_F-value between choline and acetylcholine. Sometimes it was difficult to distinguish this spot from a spot produced by choline. The spot could also be identified by exposure to iodine vapours or by pharmacological testing of strips of the filter paper.

In the related species *Buccinum* the salivary glands contain a substance resembling 5-hydroxytryptamine[4], but no such substance could be demonstrated in extracts of the *Neptunea* glands. Murexine, the choline ester found in the hypobranchial gland of

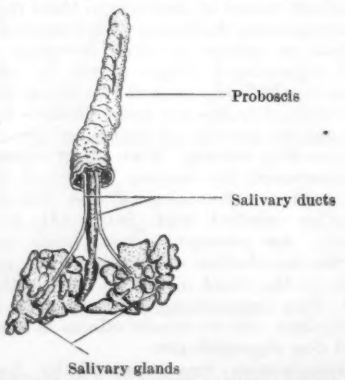

Fig. 1. Proboscis and salivary glands of *Neptunea antiqua*. The two secretory ducts follow the œsophagus and open into the mouth at the tip of the proboscis. About one-quarter natural size

Murex trunculus, has strong nicotine-like effects but almost no muscarinic effects[5]. For that reason the physiological effects from extracts of the *Neptunea* glands probably are not due to the presence of murexine. In Hokkaido in Japan food poisoning has been caused by eating *Neptunea arthritica*, and it was found that only the salivary glands and no other parts of the molluscs were poisonous[6].

Neptunea, like *Buccinum*, is a carnivorous animal, but its feeding habits are not known. Presumably, the secretion from the salivary glands is used to paralyse other animals which serve it as prey.

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Action of Copper on Mammalian β-Glucuronidase

IN studying the inhibition of partially purified mammalian β-glucuronidase by heavy metal ions, we have found that the cupric ion is a moderate inhibitor, and is potentiated by cysteine. This action of cysteine appears to be limited by the formation of cystine, since the latter reverses inhibition by copper and by other metals. Sodium bisulphite and ascorbic acid were therefore examined as alternative reducing agents. Neither of these agents by itself had any effect on the enzyme activity, but they had an identical action in potentiating inhibition by the cupric ion, as shown in Fig. 1; this process was instantaneous, there being no increase in inhibition on prolonged incubation with the substrate. In the presence of ascorbic acid or bisulphite, the inhibitory power of Cu^{++} was of the same order as that of Ag^{+} or Hg^{++}, neither of which was potentiated by the reducing agents. A feasible explanation of these results is that copper inhibition is due to the cuprous, and not the cupric, ion.

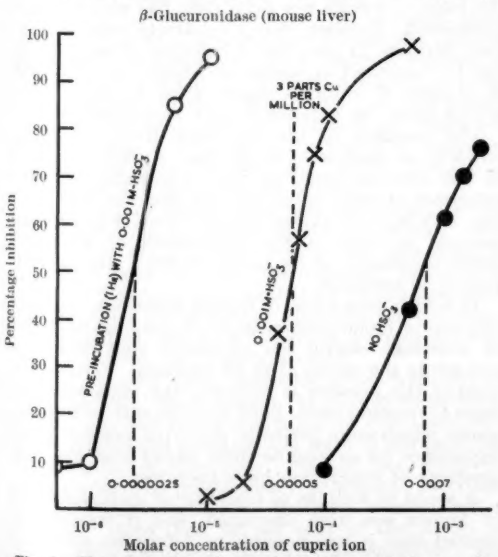

Fig. 1. The effect of cupric ions in presence and absence of bisulphite on the enzymic hydrolysis of 0·00063 *M*-phenolphthalein glucuronide in 1 hr. at 37° C. and *p*H 5·2, as compared with the effect of pretreating the enzyme at 37° C. with these reagents at the *p*H of assay

These experiments may explain conflicting statements in the literature on inhibition of β-glucuronidase by ascorbic acid[1], and may have some bearing on the inhibition of sulphatase by bisulphite[2].

When the enzyme β-glucuronidase was incubated in the presence of cupric ions and bisulphite at 37° C. for 1 hr. prior to addition of substrate for assay, the inhibition was enormously increased (Fig. 1). It was necessary to incubate all three components, enzyme, cupric ion and bisulphite, simultaneously, and the process was arrested by addition of substrate. The inhibitory power of Ag^{+} and Hg^{++} was also increased in this type of experiment, but ascorbic acid could not replace bisulphite in this reaction. It is concluded that we are measuring here an alteration in the actual enzyme molecule.

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Structure of Brain Ganglioside

THE brain gangliosides of Klenk[1] are macromolecular glycolipids of unknown structure and function, composed of neuraminic acid, sphingosine, fatty acids, hexoses and a hexosamine[1-4]. Structural evidence has now been obtained by acid hydrolytic cleavage of a highly purified preparation of brain ganglioside. A glucocerebroside has been isolated and the structure of the repeating unit formulated.

A stepwise procedure has been developed by which small fragments are successively cleaved from the water-soluble macromolecule, and separated quantitatively and gently from the balance of the molecule by exhaustive dialysis through 'Cellophane'. Both the dialysable and non-dialysable hydrolytic products are analysed at each step in terms of dry weight, titratable acidity, nitrogen, amino-nitrogen, neuraminic acid, hexosamine, hexose, and reducing sugar, partitioned by paper chromatographic and ion-exchange procedures, and the subfractions further hydrolysed and analysed. Earlier studies[2,3] have demonstrated the hexoses to be exclusively glucose and galactose, and the hexosamine to be galactosamine.

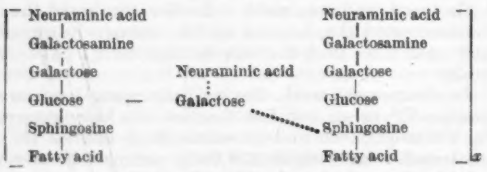
In the present work, bovine brain ganglioside was prepared[2,3] as an ash-free fraction (I) homogeneous by electrophoretic and ultracentrifuge studies (minimal molecular weight 250,000), completely water-soluble, free of phosphatides (P, 0·07 per cent) and of dialysable contaminants. (I) contains nitrogen 2·9 per cent, hexose 24·0 per cent (expressed as galactose) and galactosamine 10·0 per cent.

A 2 per cent aqueous solution of (I) is autohydrolysed at 100° C. for a critical time interval of

25 min., then exhaustively dialysed. The dialysate contains 66 per cent of the neuraminic acid and 5·2 per cent of the galactosamine of (I). The non-dialysable residue (*A*) accounts for 80 per cent by weight of (I). When (*A*) is hydrolysed (0·09 hydrochloric acid, 100° C., 50 min.), then dialysed exhaustively, the dialysate contains a further 8 per cent of the neuraminic acid, 24·2 per cent of the galactosamine, and 15 per cent of the hexose (galactose exclusively) of (I). The water-soluble non-dialysable residue (*B*) accounts for 64 per cent by weight of (I). When (*B*) is hydrolysed (6 *N* hydrochloric acid, 100° C., 5 min.), then dialysed, the balance of the neuraminic acid, galactosamine and galactose, plus some glucose, become dialysable. The non-dialysable residue contains the sphingosine and fatty acid of (I) plus 8 per cent of the hexose (glucose only). The recovery in terms of hexose and nitrogen, taking all the subfractions together, has been 96·6 and 96 per cent respectively.

The hydrolysis of (*A*), which removed galactose but no glucose, suggested that an intact glucocerebroside might be isolated. Optimal conditions were defined as follows: (*A*) is hydrolysed with 0·09 *N* hydrochloric acid (sealed tube, 100° C., 16 hr.), then dialysed. The resulting non-dialysable residue (*C*), still water-soluble, is further hydrolysed (0·09 *N* hydrochloric acid, sealed tube, 100° C., 5 hr.). The hydrolysate, which now contains a tan-insoluble material, is dialysed. The water-insoluble material is separated by centrifugation and dried *in vacuo*. It is soluble in warm methanol/chloroform (9 : 1), from which it forms birefringent spherocrystals on cooling (25° C.). To date, yields of these crystals represent between 26 and 30 per cent by weight of (I). The crystals contain nitrogen 1·8 per cent, and hexose 21·8 per cent (expressed as glucose). Neuraminic acid and galactosamine are absent. Their infra-red spectrum is consistent with that of a cerebroside. Hydrolysis of a glucocerebroside would yield glucose plus a ceramide. Hydrolysis of the crystals (1 *N* hydrochloric acid, sealed tube, 100° C., 16 hr.) liberates the hexose (exclusively glucose). The remaining water-insoluble residue contains nitrogen 2·3 per cent, as expected for a ceramide.

The constant order of release of dialysable constituents observed in repeated stepwise hydrolyses, namely, neuraminic acid, galactosamine, galactose, glucose, sphingosine and fatty acids, is suggestive of a structural sequence. Furthermore, analysis of aliquots of the hydrolytic products at particular steps revealed, in addition to a glucocerebroside, fragments of fatty acid–sphingosine, sphingosine–glucose, hexose–galactosamine and galactosamine–neuraminic acid. These and other results suggest that the repeating unit of this brain ganglioside is as follows:



Constituent (per cent) of brain ganglioside

	Calculated on the basis of the above formulation	Found
Nitrogen	2·96	2·9
Neuraminic acid	30·5	30·3
Hexose	24·4	24·0
Galactosamine	10·8	10·0

The linkages which have not yet been positively identified are shown by dotted lines. There is evidence that the constituent cerebroside base is modified in that it possesses a free reducing group, and that it is by means of glycosidic bonding between this group and a hexose of the neighbouring repeating unit that the polymerized macromolecule is formed.

The above structure, with water-soluble constituents 'facing' one way, and lipid-soluble constituents 'facing' the other, would permit the brain ganglioside to function admirably in transport phenomena occurring at the nerve cell surface. A detailed report of this work will appear elsewhere.

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Determination of the Sex of Human Abortions by Nuclear Sexing the Cells of the Chorionic Villi

Barr and Bertram[1] demonstrated the almost invariable presence of a specific body in the cells of the hypoglossal nuclei of female cats. The subsequent literature on the subject is large and has been very clearly reviewed by Lennox[2]. It seems possible that the technique of sexing cells now available may contribute to the difficult problem of determining the sex ratio in human abortions, and so indirectly to that of the early sex ratio in man. The traditional view that, so far back as can be determined, the male to female sex ratio rises has recently been questioned. Further, only a relatively small proportion, perhaps 10 per cent of embryos of sexable age, can be recovered in human abortions; so that even in respect of embryos larger than 17 mm. direct sexing must be extremely slow and laborious.

The question of the sex ratio from conception onwards in man is of more than academic interest at the present time, in that reasonably accurate estimates of early ratios are essential for estimating the validity of extrapolations from experimental animals to man of the importance of sex-linked lethal mutations to be expected from increased exposure to radiation.

In a high proportion of human abortions, chorionic villi can be found even in decidual scrapings recovered at curettage carried out to ensure that debris are not left in the uterus after an abortion. Fortunately, even if the decidua is necrotic, the embedded villi seem to remain viable. Such live villi with cells having nuclei which stain perfectly are often present in our experience for so long as three weeks after the main products of conception have been lost.

A series of sections of placentæ of mature children of known sex were examined, and it was demonstrated that it was possible to determine accurately the sex of the child by the presence or absence of 'sex chromatin' in the nuclei of the cells of the supporting tissue of mesenchymal origin in the placental villi.

Fig. 1

More important and relevant, it has also proved possible to 'sex' chorionic villi recovered from abortions at all periods of pregnancy, using the nuclei of mesenchyme cells in the supporting tissue of the villi. The nuclei of the syncytial cells and of the cytotrophoblastic Langhan's cells covering the villi have proved relatively unsuitable for the purpose, as they tend to have a very large chromatin content in the nuclei; this makes determination of the pattern inside the nucleus difficult. In addition, the Langhan's cells often overlap in cut sections.

So far, only one hundred and thirty abortions have been examined in the Department. On average, however, between four and five specimens are being received daily from two units which treat all the abortions that occur in Belfast with the exception of the odd case admitted in error or occurring accidentally in other hospitals. It is hoped that, by the end of the present year, a sufficient number will have been examined to be of value in relation to the question of sex ratio, at least in respect of abortions occurring in the eight- to twelve-week period which is the most common duration of pregnancy at which abortions occur. Concurrently, intensive recording of case fertility and family history is proceeding in respect of each abortion.

Specimens are fixed in the formalin, alcohol acetic acid fixative recommended by Moore and Barr[3], and sections are stained as a routine by hæmatoxylin and eosin and by the ribonuclease gallocyanin method[4]. The former is essential for proper identification of tissues and is usually adequate for identification of nuclear detail, provided the sections are well cleared of acid and lightly stained.

Fig. 1 shows a villus mesenchyme cell with typical 'sex chromatin' lying against the nuclear membrane. The woman had had a sharp loss of blood and clot at nine weeks, and probably lost most of the products of conception at that time. She did not, however, consult a medical practitioner; in hospital, curettage revealed only degenerate decidual tissue and a few villi. More than 90 per cent of the nuclei of villus cells counted showed unmistakable sex chromatin.

We are indebted to Prof. J. H. Biggart, who provided sections of placenta from children of known sex, so that our recognition could be checked, and to Dr. J. G. Gibson for much help and advice.

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Isolation and Cultivation of Zooxanthellae

A remarkable characteristic of tropical coral reefs, and indeed to some extent of shallow marine waters everywhere, is the profusion of single-cell, yellow-green algae (the so-called symbiotic zooxanthellae) that live within a wide variety of radiolarians, cœlenterates, molluscs, bryozoans, worms, ascidians, etc. With a few exceptions, the definite taxonomic status of zooxanthellae has been difficult because of their somewhat generalized morphology and because of the absence or elusive nature of a motile phase[1-3]; only Kawaguti[4] has reported seeing motile forms.

If, following on the work of Kawaguti, zooxanthellae could be isolated from host animals, grown serially in bacteria-free culture, and their nutritive and reproductive characteristics studied *in vitro*, not only should their identity in each case be ascertainable, but also possibly clues as to their trophic relation with the host.

We have approached the problem from this point of view, using variations of recently developed synthetic marine media[5], together with special isolation techniques. Hitherto, we have succeeded in culturing through serial passage zooxanthellae from a nudibranch (*Scyllaea* sp.), a Scyphozoan jelly-fish (*Cassiopeia* sp.), and an anemone (*Condylactis* sp.), all common forms collected in waters around Bimini, British West Indies.

The initial inoculum was either a fragment of zooxanthellae-containing host tissue or, more frequently, a suspension of zooxanthellae removed from such tissue by maceration in a Waring blendor, then centrifuged, and repeatedly washed in solutions of sterile sea water and of defined antibiotic-treated media. In the medium presently employed, inocula of 5–10,000 vegetative cells regularly show an absolute increment within 15 days to about 30 million.

Motile phases were never observed among zooxanthellae freshly taken from the host's tissue, nor in the host's enteric fluids. However, after one to four weeks in continuous low light, many algal cells of the inoculated culture tubes gave rise to motile forms the concentration of which at times reached 'bloom' proportions. Motile cells derived from *Scyllaea*, *Cassiopeia*, and *Condylactis* zooxanthellae were unequivocally observed to be flagellates of the Dinophycean group, that is, they showed (*a*) a transverse girdle, (*b*) two flagella, one enclosed in the girdle and the other extending backwards, (*c*) a characteristic spiral motility. *In vitro* reversion of motile cells to the vegetative type was observed repeatedly, and successive transfers are now routine in our laboratory.

Identification of these zooxanthellae as dinoflagellates supports earlier conclusions of Hovasse[2] and of Pringsheim[3] for corals based tentatively on the morphology of resting cells, and of Kawaguti[4], also

for coral zooxanthellae, based on observation of motile cells. On the other hand, whether zooxanthellae of all algae-harbouring animals fall into one or into multiple taxonomic groups, may not yet be said, nor whether they vary according to the season of the year or to local conditions.

Being able now to grow zooxanthellae serially *in vitro* suggests an avenue toward the possible resolution of some nutritive and general ecological problems pertaining to this widespread, perhaps fundamental plant–animal relationship. Work in this direction, as well as on the ecological distribution of zooxanthellae, continues. Details of the isolation and serial culture of the zooxanthellae described above will be published elsewhere[6].

We are grateful to Dr. C. M. Breder, director of the Lerner Marine Laboratory, Bimini, B.W.I., for having made the facilities of that institution available to us. We wish to express our thanks to the National Geographic Society of Washington, D.C., for having aided in field work which led to the initiation and development of this programme.

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Leaching of a Flower Inhibitor from Late Varieties of Peas

Barber and Paton[1,2] concluded from grafting experiments between genetically early and late varieties of garden peas (*Pisum sativum*) that the dominant *Sn* gene causing late flowering is responsible for the production of a substance delaying flowering. This inhibitor passes into the plumule from the cotyledons over a period of 10–14 days after germination. Cuttings taken soon after germination usually flower at a lower node than those taken later, or than whole plants. This effect is most marked in short-days, since the delay in flowering produced by the *Sn* gene is the greater the shorter the photoperiod (Barber and Sprent, unpublished work).

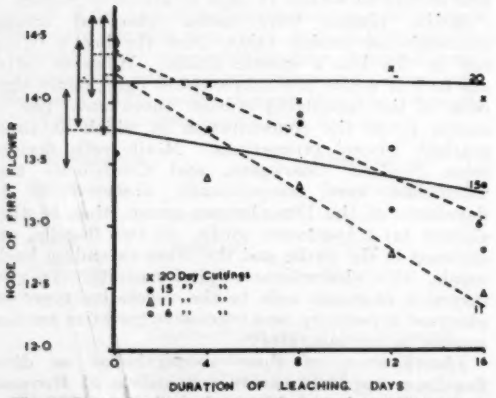

Fig. 1. Regression lines of node of first flower on leaching time for different cutting dates. Arrows indicate the 95 per cent confidence limits of the intercepts made by the lines on the *y*-axis

Table 1

Effect	Sum of squares	Degrees of freedom	Mean square	*F* ratio	Significance level
Cutting date	10·49	3	3·95	14·82	0·1 per cent
Leaching time	11·92	4	2·98	12·63	0·1 "
Interaction	8·61	12	0·72	3·04	1·0 "
Error	18·15	76	0·24	—	—

Numerous attempts using cuttings for bioassay have been made in order to isolate the inhibitor-hormone. These attempts have involved soaking young cuttings in weak solutions of a variety of chemical substances. In some of the experiments it has been noticed that controls soaked in water flower at a lower node than those planted directly in the soil. This effect was investigated further using the late variety Greenfeast in a factorial experiment combining cuttings taken at 6, 11, 15 and 20 days after germination and soaked in water for 0, 4, 8, 12 or 16 days before planting into the soil. The experiment was carried out in summer under natural photoperiod (about 16 hr.). The results for node of first flower are shown in Fig. 1, with the analysis of variance in Table 1. It is clear that the leaching of young cuttings leads to flowering at a lower node.

In order to analyse the effect more precisely, regression lines of node of first flower on time of leaching are given in Fig. 1 and the regression analysis of variance in Table 2. The slopes of the regression lines show that the leaching effect is greatest if the cuttings are taken 6–11 days after germination (at this stage two to four internodes are fully expanded). These relationships are, of course, responsible for the significant interaction between time of leaching and date of cutting.

In addition to node of first flower, the cuttings were scored for vegetative growth as measured by shoot-length, number of expanded internodes, node at which the first leaf with four leaflets is produced and on an arbitrary general growth scale. No correlation of any of these quantities with node of first flower was observed. The results, therefore, are best explained by the leaching out of a flower-inhibitor which is still in a labile phase following transport from the cotyledons. After 15–20 days from germination, the inhibitor becomes incorporated into the cytoplasm and can no longer be removed. At this stage soaking in water has no effect on flowering of cuttings. Analyses to identify the substances leached out of the young cuttings are being carried out.

Table 2. Regression Analyses of Variance

Type of cuttings	Effect	Degrees of freedom	Mean squares	Significance level
6 day	Regression	1	4·41	0·1 per cent
	Deviations	3	0·63	5·0 "
	Error	20	0·17	
11 day	Regression	1	8·69	0·1 "
	Deviations	3	1·09	n.s.
	Error	20	0·38	
15 day	Regression	1	0·56	10·0 "
	Deviations	3	0·42	n.s.
	Error	20	0·15	
20 day	Regression	1	0·09	n.s.
	Deviations	3	0·11	n.s.
	Error	20	0·26	

We wish to acknowledge financial assistance from the Rural Credits Division of the Commonwealth Bank of Australia. The work was carried out while one of us (J. S.) held the I.C.I.A.N.Z. Research Fellowship of the University of Tasmania.

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Partial Enzymic Degradation of *Tamarindus*-Amyloid

HEATED cellulase of *Myrothecium verrucaria*[1] degrades the amyloid of *Tamarindus indica* to a product which by means of paper chromatography (applying butanol/pyridine/water/benzene (5 : 3·2 : 3 : 0·45) as a solvent and developing for a week) appears to contain at least eight oligosaccharides, three of them occurring as the main products. These three oligosaccharides, *A*, *B* and *C*, could be shown to be a hepta-, an octa- and a nona-saccharide respectively, and are composed of 4 glucose residues, 3 xylose residues and 0, 1 and 2 galactose residues respectively. They are liberated in a molar ratio of roughly 2 : 5 : 6. The three oligosaccharides constitute a homologous series; this was confirmed by the facts that: (1) the values of log $R_F/(1-R_F)$ lie on a straight line when plotted against degree of polymerization[1], and (2) the values of $[M]n/n$, when plotted against $(n-1)/n$, lie on a straight line as well[2].

Amyloids from seeds of other plant species can also be hydrolysed by cellulase. On paper chromatograms the oligosaccharides from the amyloids investigated (from *Tropaeolum majus*, *Cyclamen* hybr., *Impatiens balsamina*, *Hymenaea courbaril*, *Schotia latifolia*) have mobilities which suggest that in all instances the oligosaccharides are the same as those from the amyloid of *Tamarindus*. The ratios in which the oligosaccharides appear are different for different species. *Tropaeolum* amyloid is hydrolysed by cellulase to give the three oligosaccharides in a molar ratio of roughly 1 : 2 : 10. *Cyclamen* amyloid gives the oligosaccharides *A*, *B*, *C*, and *D* in a molar ratio of approximately 2 : 7 : 2 : 2. (Oligosaccharide *D* occurs in cellulase hydrolysates of *Tamarindus* and *Tropaeolum* amyloids only in negligible amounts, whereas in *Cyclamen* amyloid the amount is much larger.)

The specific rotations of the oligosaccharides *C* from the amyloids of *Tamarindus*, *Tropaeolum* and *Cyclamen* are: $[\alpha]_D^{18°C.} = 73·0°$, 74·6° and 75·6° respectively ($c = 1$, water). The correspondence of the specific rotations and of the chromatographic behaviour of the oligosaccharides *C* suggests that they are identical. Oligosaccharides *A* may also be identical, as well as the oligosaccharides *B*.

It is apparent that the amyloids of seeds have constitutions which are highly interrelated.

Details of this work will be published elsewhere.

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Delft. March 21.

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Formation of β-1,4-Oligoglucosides by Certain *Acetobacter* Species

RECENT studies[1] in these laboratories have revealed the presence of cellobiose, cellotriose and cellotetraose in cellulose-producing cultures of *Acetobacter aceti-genum*, *NCIB* 8132. The present communication deals with an extension of this work in which other cellulose-producing cultures were examined for the presence of β-1,4-oligoglucosides. Mutant organisms unable to produce extracellular cellulose (celluloseless mutants) were also studied.

The cellulose-producing cultures examined were *Acetobacter acetigenum*, *NCIB* 8132, *A. xylinum*, *NCIB* 8034 and *A. xylinum* var. *africanum*, *NCIB* 7029; these cultures were obtained from the National Collection of Industrial Bacteria, Teddington, Middlesex. Cultures of celluloseless mutants were isolated from the wild-type cultures by methods described previously[2]; these are 'natural' mutants which occur spontaneously, that is, without treatment of the parent culture with mutagenic agents. Two mutant cultures were examined from each of organisms *NCIB* 8132 and *NCIB* 8034 and one from organism *NCIB* 7029. The parent and the mutant organisms were grown in a medium (*p*H 6·0) which contained the following components (per cent, w/v) in distilled water: glucose, 3·0; dibasic potassium phosphate, 0·3; ammonium sulphate, 0·3; magnesium sulphate heptahydrate, 0·2; calcium pantothenate, 0·0002; riboflavin, 0·0002; and biotin, 0·00003. One litre of medium, dispensed at 250 ml./mould culture-flask[3], was inoculated with the desired test organism and after ten days incubation at 28° the contents of the four flasks were pooled and processed as follows. The bacteria were removed by Seitz filtration of the medium, solid barium carbonate (0·5 gm.) was added, the solution was concentrated (*in vacuo*, below 40°) to about 200 ml. and then passed through a charcoal–'Celite' column[4] to separate the oligosaccharides. Elution with water, 7·5 per cent (v/v) ethanol and 20 per cent ethanol (1·5 l. of each), respectively, gave fractions 1–3. A fourth fraction was obtained by boiling the charcoal–'Celite' mixture in 30 per cent ethanol[5]. All fractions were concentrated to about 20 ml. (*in vacuo*, below 40°), deionized with 'Zeo-Karb 225 (H)' and then with 'Amberlite *IR*-4*B* (OH)'. After removal of the resin, the solutions were concentrated to syrups and examined for the presence of oligosaccharides by paper chromatography[6].

A sugar component with an R_F value similar to that of authentic glucose was found in all fractions, thus indicating that a complete separation of the sugars had not been achieved. However, fraction 3 obtained from each parent culture showed a sugar which corresponded in mobility to authentic cellobiose; also, a similar fraction obtained from organisms *NCIB* 8132 and *NCIB* 7029 showed a sugar corresponding in movement on the paper to cellotriose. These findings were supported by chromatography of these sugars as their *N*-benzylamine derivatives[7]. No attempt was made to identify other sugars present. Examination of the five mutant cultures failed to reveal sugars with mobilities similar to authentic cellobiose or cellotriose in any fraction.

The accumulation of cellobiose and cellotriose in cellulose-producing cultures and the absence of detectable amounts of these sugars in cultures of celluloseless mutants strengthens the hypothesis that these sugars are concerned in the synthesis of bacterial cellulose, although it is not a rigid proof of this. If

these sugars are in fact intermediate products, then it would appear that the block in the mechanism of cellulose synthesis, in all the mutant cultures examined, occurred at a stage prior to the formation of cellobiose. Cultures of mutant organisms did not produce cellulose when grown in a medium containing cellobiose.

One of us (R. S.) acknowledges the receipt of an Imperial Chemical Industries Research Fellowship.

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Thomas K. Walker

College of Science and Technology,
University of Manchester.
April 1.

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Phototropism of *Phycomyces* Sporangiophores

In a recent communication, Curry and Gruen[1] reported that sporangiophores of *Phycomyces blakesleeanus* showed strong negative phototropism when exposed to wave-lengths shorter than 300 mμ in addition to the positive phototropism in visible light known to earlier workers. They also showed that this negative response was due to a temporary increase in growth-rate on the side of the sporangiophore nearest the source of light, as they were able to demonstrate a 'light-growth reaction'.

Blaauw[2] demonstrated a 'light-growth reaction' in sporangiophores exposed to visible light, and therefore concluded that positive phototropism must be due to a temporary increase in growth-rate on the far side of the sporangiophore. Castle[3] showed geometrically that the path-length for light was greater in the far half than in the near half of the sporangiophore, owing to a 'lens-effect'. Therefore, provided that the absorption coefficient of the sporangiophore did not exceed a critical value, greater photochemical action could occur in the far half of the sporangiophore than in the near half. Banbury[4] achieved a virtually complete proof of the hypothesis by showing that if one side only of the sporangiophore was illuminated by a grazing beam of light, a temporary increase in growth-rate occurred on that side.

It is therefore clear that radiation of wave-length less than 300 mμ produces a 'light-growth reaction' on the near side and that longer wave-lengths produce a 'light-growth' reaction on the far side. It is suggested that the reason is that at 300 mμ the absorption coefficient of the cell reaches Castles's critical value, and that at shorter wave-lengths the 'lens effect' does not succeed in bringing about greater photochemical activity in the far side of the cell than in the near side. This suggestion is plausible, since a number of the constituents of protoplasm absorb strongly only at wave-lengths less than 300 mμ. A critical test would appear to be the illumination of sporangiophores with light of 302 mμ wave-length, which does not cause any phototropic response, and to find whether a 'light-growth reaction' occurred. A positive result would confirm the theory.

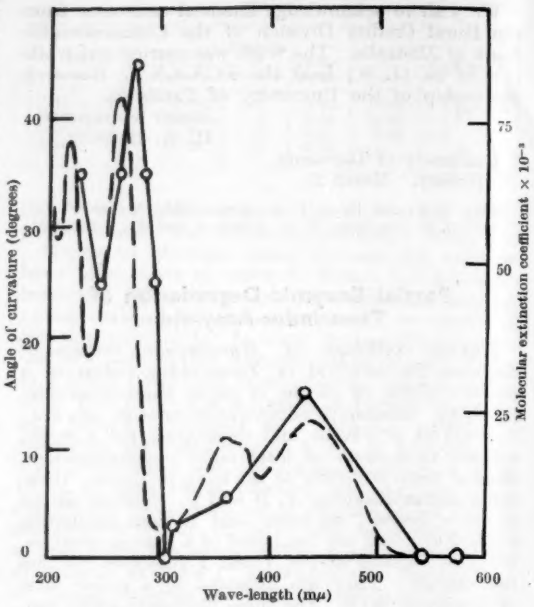

Fig. 1. Action spectrum of phototropic response, —O—. The means of Curry and Gruen's values for angle of curvature of sporangiophore are taken. Absorption spectrum of riboflavin, – – –

Provisionally assuming the correctness of the theory, the results of Curry and Gruen can be plotted as an action spectrum (Fig. 1), the sign of the phototropic response being ignored. It will be seen that the curve agrees closely with the absorption spectrum given for lactoflavin[5], now known to be identical with riboflavin. The major peak of the action spectrum is, however, at 280 mμ while the corresponding riboflavin maximum is at 265 mμ. This would be explicable if the riboflavin is the prosthetic group of a protein, as this, by analogy with flavin adenine dinucleotide[6], would be likely to shift the spectrum about 15 mμ towards the red.

Brauner[7] summarizes the reasons for regarding phototropism as being due to a riboflavin-sensitized destruction of indolyl acetic acid. In higher plants the destruction of indolyl acetic acid leads to reduced growth-rate, whereas in fungi, he suggests, the concentration of indolyl acetic acid is already supra-optimal and its destruction leads to an increased growth-rate. The above discussion shows that the results of Curry and Gruen may be interpreted as showing that both positive and negative phototropism in *Phycomyces* is due to a single riboflavin-mediated response.

I wish to thank Dr. L. E. Hawker and Prof. E. W. Yemm for helpful discussion.

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APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned :

DEMONSTRATOR (with an honours degree in chemistry or biochemistry, and prepared to engage in research in biochemistry with a view to obtaining a higher degree) IN THE DEPARTMENT OF CHEMISTRY AND BIOCHEMISTRY—The Dean, St. Thomas's Hospital Medical School, London, S.E.1 (August 1).

HOSPITAL PHYSICIST (Senior or Basic grade) IN THE RADIOTHERAPY DEPARTMENT—The Secretary, North Middlesex Hospital, London, N.18 (August 2).

SCIENTIFIC OFFICER (with a good honours degree in science) for genetical and breeding research in field beans and forage crops—The Secretary, Plant Breeding Institute, Trumpington, Cambridge (August 2).

SPECIAL ANALYSIS RESEARCH OFFICER (with a postgraduate degree, preferably Ph.D., from a recognized university, and basic training in geology) IN THE DIVISION OF BUILDING RESEARCH, National Research Council of Canada, to carry out research relating to building materials, involving petrographic, X-ray diffraction and differential thermal analysis methods for the identification of minerals in clays, and concrete aggregates and special chemical constituents of concrete—Chief Scientific Liaison Officer, National Research Council of Canada, Africa House, Kingsway, London, W.C.2 (August 2).

ASSISTANT, Grade B (graduate, with research or industrial experience) IN METALLURGY—The Principal, Derby and District College of Technology, Normanton Road, Derby (August 3).

JOHN STOKES RESEARCH FELLOW to carry out in one of the departments of Sheffield University Medical School or in a teaching hospital associated with the Medical School, original research work in some branch of medical science approved by the Advisory Committee—The Registrar, The University, Sheffield (August 3).

SENIOR LECTURER (with industrial and/or research experience, and capable of initiating and supervising the work of research assistants) to teach electronics and physics to B.Sc. General and Special students —The Registrar, College of Technology, Suffolk Street, Birmingham (August 3).

ASSISTANT LECTURER (with special interests or training in experimental and statistical psychology) IN PSYCHOLOGY—The Registrar, The University, Manchester (August 10).

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CHEMIST (with a good honours degree, and preferably previous experience of radiochemical and analytical work) to take charge of a laboratory examining radioactive substances in biological materials—The Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1 (August 12).

ASSISTANT EXPERIMENTAL OFFICER (with a pass degree or equivalent qualification) IN THE DEPARTMENT OF PHYSIOLOGY AND PLANT CULTURE, to act as personal Research Assistant to the Head of the Department—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford (August 14).

MINING CONSULTANT (not under 45 and preferably not over 55, with a wide and varied experience of deep and open-cast mining, and previous experience in a consultative and advisory capacity to important mining concerns) with the Government of Tanganyika, to advise the Government on technical matters relating to the mining industry and to act in a consultative capacity to mining undertakings operating in Tanganyika and requiring professional advice and assistance—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.99/8/02 (August 15).

CHAIR OF ENGINEERING—The Registrar, The University, Southampton (August 17).

DIRECTOR OF THE ELECTRONIC COMPUTATION LABORATORY IN THE DEPARTMENT OF APPLIED MATHEMATICS—The Registrar, The University, Sheffield (August 17).

LECTURER/SENIOR LECTURER (preferably with research experience in supersonics and boundary layer theory) IN AERONAUTICAL ENGINEERING at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 17).

STUDENT IN THE DEPARTMENT OF CHEMISTRY, for research on the pyrolysis of high molecular weight organic compounds and the investigation of the carbons so produced, especially by adsorption techniques—The Registrar, The University, Hull (August 19).

READER IN ELECTRICAL ENGINEERING at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (August 22).

FUEL TECHNOLOGIST or PHYSICAL CHEMIST (with a university honours degree in science, applied science or fuel technology, together with some postgraduate research experience, preferably in coal preparation) IN THE COAL RESEARCH SECTION, Commonwealth Scientific and Industrial Research Organization, North Ryde, Sydney, N.S.W., to initiate research and to undertake investigations in coal washing and preparation, with emphasis on the cleaning of fine coal—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Ref. No. 480/225 (August 24).

RESEARCH ASSISTANT (with research experience (academic or industrial) in polymer science) IN THE DEPARTMENT OF CHEMISTRY, to assist in a programme of work on the synthesis of polyethers and a study of their physical properties—The Registrar, The University, Manchester 13 (August 26).

CHAIR OF BACTERIOLOGY in the University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 31).

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LECTURERS (2) IN MATHEMATICS at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, August 31).

PROFESSOR OF MECHANICAL ENGINEERING at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 31).

SENIOR LECTURER IN PHYSICAL CHEMISTRY at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 31).

STATISTICIAN, SENIOR SCIENTIFIC OFFICER or SCIENTIFIC OFFICER grade (with an honours degree and statistical training or experience) ; and an ASSISTANT EXPERIMENTAL OFFICER (graduate in botany, horticulture or agriculture with mathematical aptitude, or in mathematics or statistics with biological interests)—The Secretary, East Malling Research Station, near Maidstone, Kent (August 31).

LECTURER IN GEOLOGY at Rhodes University, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, September 1).

LECTURER or ASSISTANT LECTURER (with a higher degree in biochemistry or physiology) IN BIOCHEMISTRY—The Secretary and Registrar, The University, Southampton (September 7).

STATISTICIAN (with an honours degree or postgraduate diploma in statistics or equivalent, and a special interest in biometry and design and analysis of experiments)—The Secretary, The University, Aberdeen (September 7).

COWBURN RESEARCH FELLOW (not necessarily medically qualified) to undertake research on blood coagulation in relation to human disease—The Secretary, King's College Hospital Medical School (University of London), Denmark Hill, London, S.E.5 (September 14).

FIELD GEOLOGIST (graduate in geology) with the Geological Survey of Greenland, to undertake field work in the Precambrian of South Greenland—The Director, Geological Survey of Greenland, Grønlands Geologiske Undersøgelse, Østervoldgade 7, Copenhagen K., Denmark (September 15).

SENIOR LECTURER IN CIVIL ENGINEERING ; and a LECTURER IN CIVIL ENGINEERING at Canterbury University College, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, September 30).

ANALYST (with a science degree with chemistry as one subject, and preferably a knowledge of bacteriology) in the Northern Region of Nigeria, for the chemical and bacteriological analyses of water and foods—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.97/408/03.

ASSISTANT LECTURER IN ORGANIC CHEMISTRY—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8.

CHEMISTRY GRADUATE for research work IN THE CHEMISTRY DEPARTMENT on problems of physical-organic chemistry with particular relation to organo-phosphorus compounds—The Registrar, Queen Mary College, Mile End Road, London, E.1.

EXPERIMENTAL ASSISTANT (with at least G.C.E. including one science subject, and preferably a fondness for outdoor work and ability to drive) IN THE DEPARTMENT OF AGRICULTURAL BOTANY, for responsible field and laboratory work on crops—The Bursar, The University, Reading, Berks.

LABORATORY ASSISTANT (with sufficient experience of school or university work to take charge of the Chemistry Laboratories)—The Bursar, The College, Cheltenham.

LECTURER (graduate in pharmacy and/or Fellow of the Pharmaceutical Society or equivalent qualifications, and preferably industrial, research and teaching experience) IN PHARMACEUTICS, at the City College of Technology, Byrom Street, Liverpool—The Director of Education, 14 Sir Thomas Street, Liverpool.

LECTURER (with academic qualifications and postgraduate experience in physical chemistry) IN THE CHEMISTRY DEPARTMENT—The Clerk to the Governing Body, Battersea College of Technology, London, S.W.11.

RESEARCH FELLOW, and a RESEARCH SCHOLAR IN THE DEPARTMENT OF CHEMISTRY, for work on organo-silicon compounds—The Registrar, The University, Leicester.

RESEARCH FELLOW IN THE DEPARTMENT OF PATHOLOGY, to investigate the serological aspects of neoplasms—The Dean, Guy's Hospital Medical School, London, S.E.1.

SENIOR LECTURER IN ELECTRICAL ENGINEERING at Bradford Institute of Technology—The Director of Education, Town Hall, Bradford.

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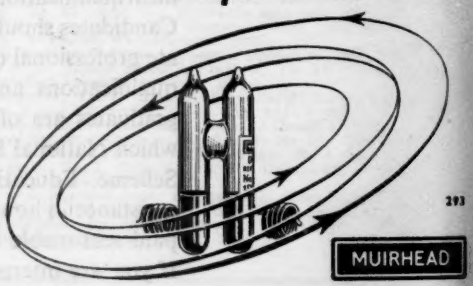

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